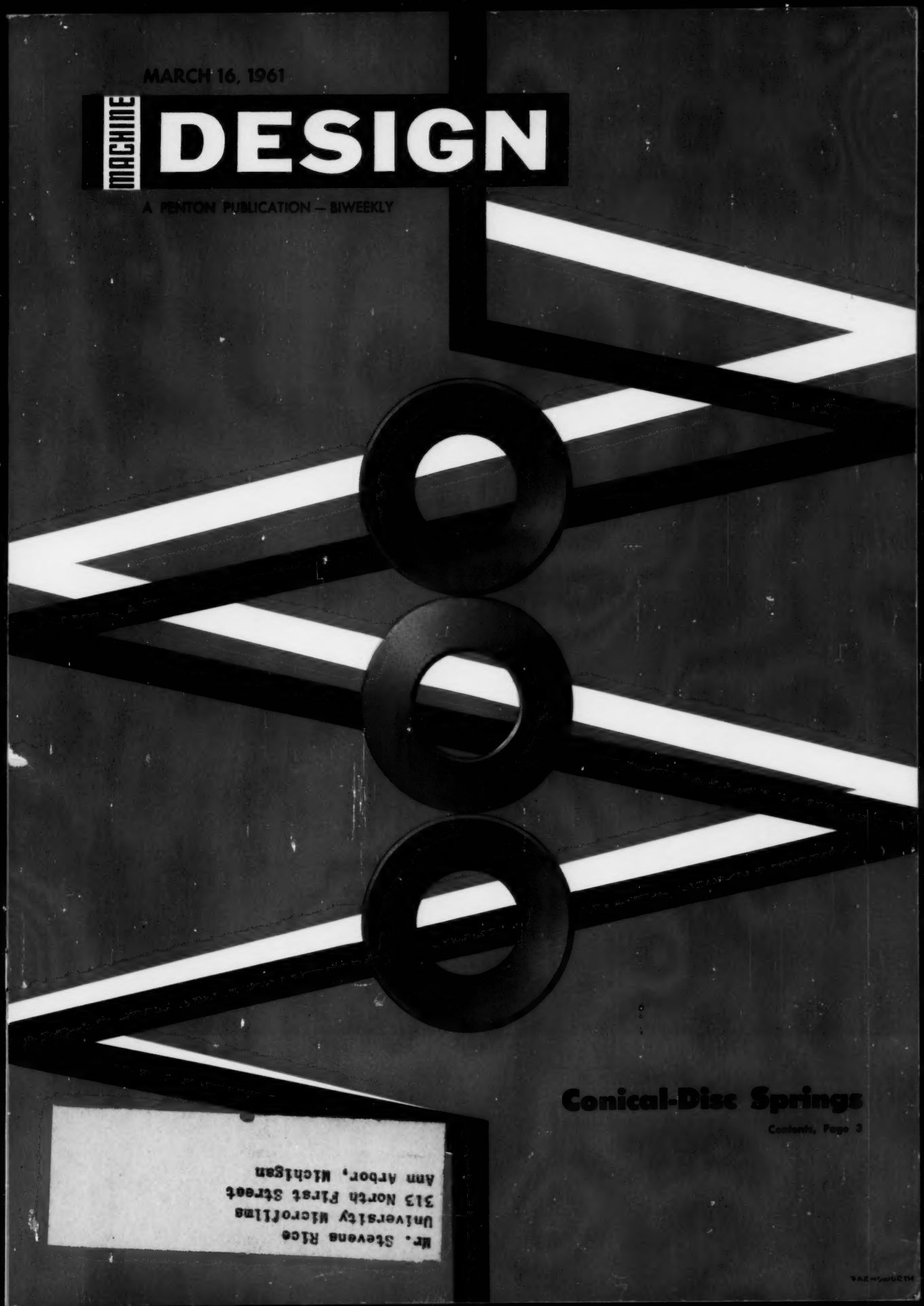
MARCH 16, 1961

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Conical-Disc Springs

Contents, Page 3

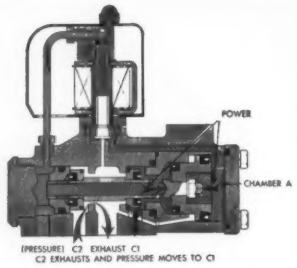
Mr. Stevens Rice
University Microfilms
313 North First Street
Ann Arbor, Michigan

ABSOLUTELY TIGHT SEATING!

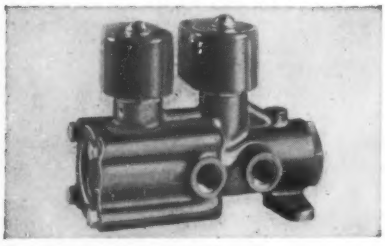
WITH ASCO POPPET TYPE 4-WAY SOLENOID VALVES

Dead tight shut-off—even on air—is assured in these four-way valves through poppet seals, and by a unique combination of metal to metal and resilient seating. No lapping, grinding or close adjustments are necessary — no binding or leaking can occur. Short piston disc assembly travel, basic design simplicity eliminate maintenance problems.

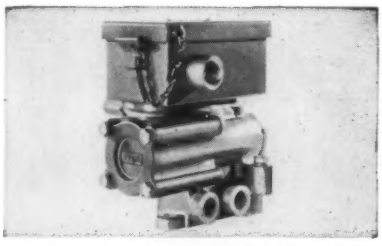
ASCO 4-way Valves are available in ⅜″ through 1″ sizes, in standard, explosion-proof or water tight enclosures. They can be mounted in any position, and permit cycling rates to 850 per minute.



Operation: ASCO Single Solenoid 4-way Valves are power-driven in both directions by line pressure. When the solenoid is de-energized, line pressure applied to the top of the piston core forces it off the seat, eliminating possible sticking due to residual magnetism. Line pressure is applied to Chamber A, moving the piston-disc assembly to the left. When the solenoid is energized, Chamber A is exhausted and line pressure drives the piston to the right. Single solenoid type (illustrated) operates when solenoid is energized; returns automatically when de-energized.



Dual Solenoid (Bulletin 8344): operates when either solenoid is energized; will not return until opposite solenoid is energized (single solenoid types return when de-energized). In dual solenoid valves, solenoids may be energized continuously or momentarily.



J.I.C. Construction (Bulletin 8346) ASCO Single and Dual Solenoid Valves can be furnished to Joint Industry Conference requirements—valves are provided with subplates, vapor-proof solenoid enclosures, and manual overrides, and are electrically inoperative with the cover removed.

New! Catalog No. 202 covers the ASCO line of Solenoid Valves. Write for your copy today.

For Immediate Delivery... World's largest stock of Solenoid Valves. A complete Solenoid Valve Stock List will be sent to you with your copy of Catalog No. 202.

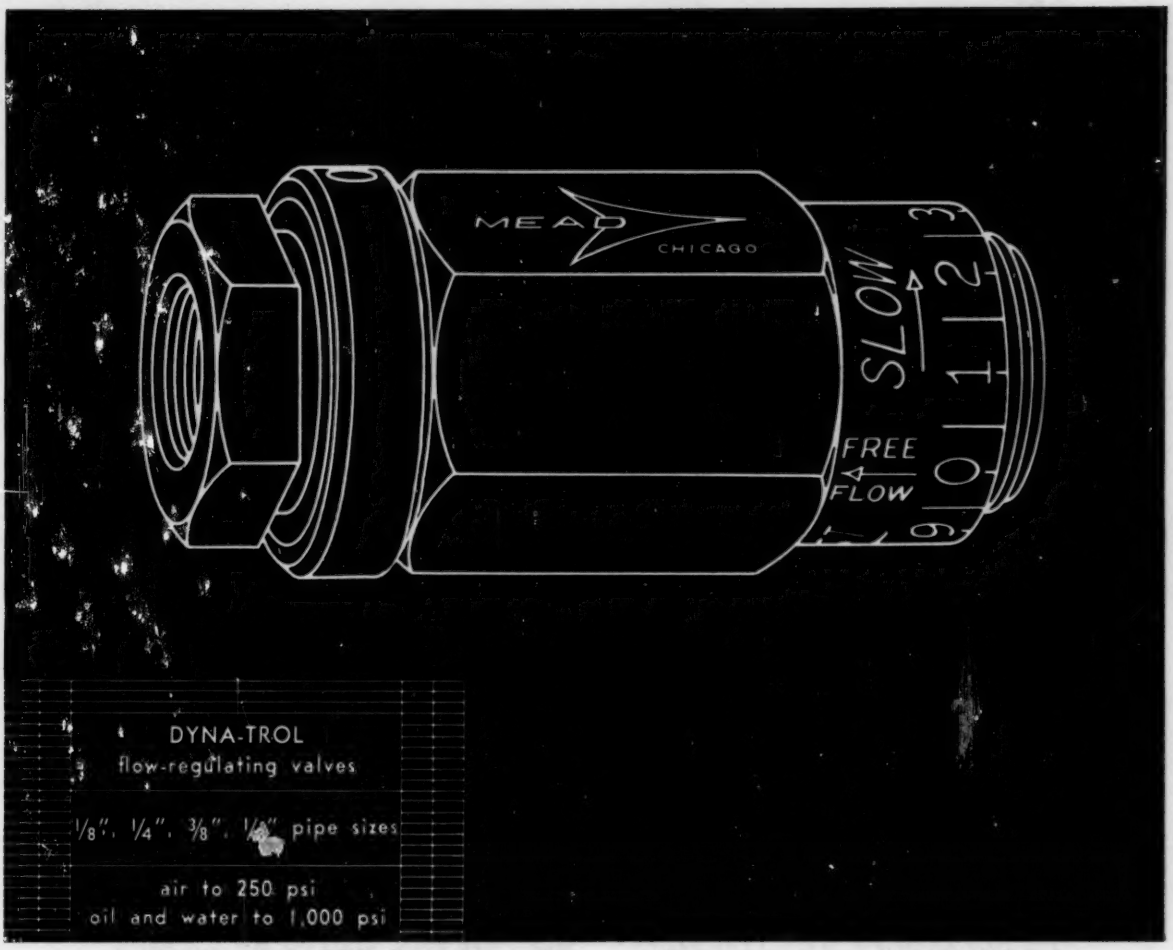
Circle 401 on Page 19

ASCO Valves

Automatic Switch Co. 54-A HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600

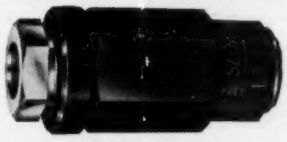
AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

ASCO®



PROBLEM: how to replace a 1/4" valve with a less-costly 1/8" valve (and get extra precision in low-flow ranges)

SOLUTION: NEW MEAD DYNA-TROL VALVE



Check these design advantages of the new MEAD DYNA-TROL flow-regulating valve:

- Adjusting sleeve — easily rotated by hand — locks to any setting and cannot be accidentally removed from valve body
- Calibrated sleeve records settings for future reference
- Knife-edge variable orifice reduces flow distortion caused by viscosity changes in working medium
- No internal springs to cause malfunction
- All parts rust-proof
- Wide operating range: −40° F. to +250° F.

Small, economical MEAD DYNA-TROL flow-regulating valves can replace more costly valves of larger pipe size. Reason: Internal design permits pneumatic or hydraulic flow equal to full pipe area in both directions. The first 360° turn of the adjusting sleeve increases flow from zero to about 10% of potential — a new measure of precision in low-flow ranges. Successive turns accurately reach 100% of pipe capacity. To cut costs and give exacting control to piston speeds, specify MEAD DYNA-TROL valves to solve your flow regulating problems. For information on quick delivery, write to MEAD *today*.

PRODUCTS FOR AUTOMATION

MEAD FLUID DYNAMICS

A DIVISION OF MEAD SPECIALTIES CO.
4114 N. KNOX AVE., Dept. 1051 CHICAGO 41, ILL.

ASK YOUR MEAD MAN for more dollar-saving automation ideas

Circle 404 on Page 19

MINNESOTA MR RUBBER

FACTS for FILING on SILICONE

For Unusual Requirements SILICONE is the answer!

Silicone rubber has been found by many designers to be the material needed for their "special" application. Whether you are designing space vehicles, high-performance aircraft components, radar or electronic components, parts for nuclear applications, or seals for use in an automatic transmission or steam iron you too will probably be able to improve your product through the use of silicone. In many of these applications, silicone with its unusual properties is a must.

To make silicone even more useful to designers, Minnesota Rubber fabricates parts by injection molding. This exclusive method of molding produces parts which are completely uniform in all respects. You know exactly what you are getting when you specify silicone parts or extrusions from Minnesota Rubber.

TYPICAL PROPERTIES OF MINNESOTA RUBBER SILICONE COMPOUNDS:

Temperature range	−130 to 500° F
Tensile strength, psi	600 to 900
Tear strength, lb/in	40 to 75
Elongation, %	150 to 300
Compression set, % @ 300° F	15 to 40
Hardness range, durometer	20 to 90
Dielectric strength, volts/mil	400 to 500

Oil resistance, depending on oil—good to excellent

FOR MORE INFORMATION ON SILICONE **WRITE:**

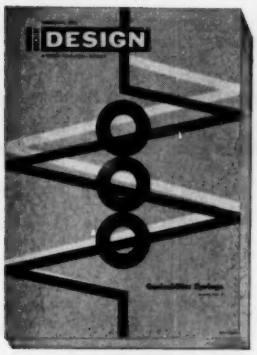
MINNESOTA MR RUBBER

NFPA

FREE COVER TO BIND YOUR MR "FACTS FOR FILING" PAGES

DEPARTMENT 818 • 3630 WOODDALE AVENUE
MINNEAPOLIS 16, MINNESOTA

OFFICES in: NEW YORK • PHILADELPHIA • CLEVELAND • BUFFALO • DETROIT • CHICAGO • MILWAUKEE • ST. LOUIS • DENVER • HOUSTON • LOS ANGELES • PORTLAND • QUAD CITIES • ST. JOSEPH, MICHIGAN • DALLAS



Front Cover: The ups and downs of conical-disc springs provide the theme for artist George Farnsworth's cover design. Arthur D. Brickman smooths things out on Page 141 with his simplified method for designing these compact springs.

March 16, 1961

Electric Engines for Power in Deep Space **26**

DONALD BOLDMAN—*News Report*—A look at electrothermal, ion, and magnetohydrodynamic engines as possible sources for low-thrust power outside gravity fields.

Engineering or Research **130**

DELMAR W. KARGER and ROBERT G. MURDICK—How company size and product affect the relative emphasis placed on engineering and research functions.

Conical-Disc Springs **141**

ARTHUR D. BRICKMAN—A simplified approach for designing springs with specific load-deflection characteristics in a minimum amount of space.

Self-Sealing Couplings **146**

RAY H. KING—How to select air and hydraulic couplings which provide instant connection and disconnection and eliminate line draining or priming.

Inverted Slider-Crank Mechanisms **159**

GEORGE A. BUCCI—An approximate equation for finding the relationships in a system where a rotating crank produces large-amplitude pinion oscillation.

Pressure-Tight Gray-Iron Castings **162**

CHARLES F. WALTON—A design guide to factors which make gray iron suitable for pressure-tight applications: Nonporosity, soundness, strength, machinability, rigidity.

Spiroid Gearing **165**

WOODROW D. NELSON—*Part 3: Materials, Mounting Details, Lubrication*—Essential assembly and manufacturing details in the design of a Spiroid gear system.

The Optical Wedge **172**

JOHN E. JUDD—A simple method for measuring vibration amplitudes.

Variable-Section Beams **173**

LAWRENCE L. MARGOLIN—*Data Sheet*—How to calculate slopes and deflections of loaded beams when material is uniform but bending moment and moment of inertia vary.

Metals at Low Temperatures **182**

R. E. LISMER—*Design Abstracts*—Low-temperature data on copper and copper alloys, nickel alloys, austenitic stainless steels, and low-carbon nickel steels.

CONTINUED NEXT PAGE

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

March 16, 1961
Volume 33 — No. 6

E & R 129
COLIN CARMICHAEL—*Editorial*

Engineering News 6

Cessna in-line twin 6
Graduate-student data 6
Thermoelectric cooling 8
Optical radar 10
Titanium casting 12
Tiny diodes 12
Chrysler gas turbine 14
Sodium fuel cell 34
Thermal drill 36
Metals Matters 39

Trends 22
Picture Report 24
Meetings and Shows 39
Short Courses and Symposia 45

Scanning the Field for Ideas 135

Stroboscope-illuminated scale indicates transmitted torque—liquid stop limits return stroke of piston—flexible-flap valve controls air access to vacuum lifter—fluidizing gas provides low-friction support—integrally cast joint reduces number of parts—balanced throttling valve reduces effect of inlet-pressure variation—alternate power paths provide quick-change gear ratios—compound venturi increases efficiency of fluid introduction—cam-controlled magnet provides reference input.

Design in Action 152

Snow rides jet air stream to eliminate fall-out—truss design eliminates bending moments in pump frame—gate control detects and removes foreign particles—moving-belt distilling system spots hot contamination—packaged hydrostatic transmission splits power for stepless drive—two different systems use work-to-heat converters for dynamic braking.

Tips and Techniques

Eraser-fluid applicator 145

Design Abstracts 182

New Parts and Materials 202

Engineering Department Equipment 234

The Engineer's Library 243

Noteworthy Patents 252

Backtalk 270

Helpful Literature 194

Subject Index 17
Reader Service Cards 19
Advertising Index 269
Business Staff 269

IN THE NEXT ISSUE: Three-wheeled transport . . . from engineer to manager . . . fatigue in metal joints . . . alignment in simple assemblies . . . precision snap-action switches . . . internal-combustion engines . . . helical spring design . . . tees in bending.

COLIN CARMICHAEL, Editor

BENJAMIN L. HUMMEL, Executive Editor
ROBERT L. STEDFELD, Managing Editor

Senior Associate Editors
LEO F. SPECTOR
WILLIAM S. MILLER

Associate Editors
SPENCER R. GRIFFITH
JAMES A. PARKS
MELVIN E. LONG
JESSE W. HUCKERT
CLARE E. WISE
DONALD R. DREGER

Assistant Editors
THEODORE M. LEACH
STANLEY G. COOK
RICHARD A. JACOBSON
JOHN J. HOSTAK
SAMUEL E. BARNES
JOSEPH M. HOMITCH
FRANCIS J. LAVOIE
LEONARD B. STANLEY
JANE H. SMITH
MARIAN L. EICHAR

Art Editors
FRANK H. BURGESS
ROBERT L. TUFTS

PUBLISHER
ROBERT L. HARTFORD

EDITORIAL OFFICES
Penton Building, Cleveland 13, Ohio

Branch Offices
New York, Detroit, Chicago, Pittsburgh, Washington, London

©1961 by The Penton Publishing Co. All rights reserved.

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

MIDVAC INCREASES STRESS RUPTURE LIFE 6 TIMES FOR JET TURBINE PARTS

MIDVAC STEELS ARE PRODUCED BY THE MIDVAC PROCESS OF CONSUMABLE ELECTRODE MELTING

When maximum reliability in the high temperature range and minimum rejects are required that's the place to specify Midvac Steels. These steels assure super alloys of increased tensile, higher impact properties, improved stress rupture strength at elevated temperatures and longer fatigue life.

As an example air melted No. 901 had excellent high temperature strength, but often failed slightly below the required stress rupture hours (15) with little to spare over the minimum ductility requirements. Well over 100 hours can be attained with Midvac melted No. 901.

The Midvac Process of consumable electrode melting eliminates atmospheric contamination, ingot soundness is improved, segregation is reduced, workability is increased and product quality is stepped-up. Midvac Steels are offered in many alloys as billets or forgings to meet the most critical design specifications of jet engine parts, missile and aircraft components and other products requiring properties beyond the capabilities of conventional steels. Let M-H metallurgists help you select the right alloy to meet your product's specifications. Write . . .

MIDVALE-HEPPENSTALL COMPANY • NICETOWN, PHILADELPHIA, PA.
SUBSIDIARY OF HEPPENSTALL COMPANY, PITTSBURGH, PA.
Plants: Pittsburgh, Pa. • Bridgeport, Conn. • New Brighton, Pa.

H MH *Midvac Steels*

VACUUM AND CONSUMABLE ELECTRODE STEELS • BACK-UP ROLL SLEEVES • FORGED STEEL ROLLS • FORGINGS
RINGS • PRESSURE VESSELS • INDUSTRIAL KNIVES • DIE BLOCKS • MATERIALS HANDLING EQUIPMENT

Circle 406 on Page 19

Twin cantilever tail booms, extending back from each wing, support individual rudders and a stabilizer.

In-Line Twin Aims at Single-Engine Safety

WICHITA, KANSAS—Engine-out procedures for a conventional light twin, while routine for the high-time professional, can put the business-man pilot in a fix if he makes the wrong moves. Cessna Aircraft has cut the operation to the minimum in Skymaster—a revolutionary four-place business plane with tractor-pusher twin powerplants.

Announcing first flights for the Skymaster, Cessna said it will cover more of the utility transportation spectrum than any other twin-engine airplane. The engine arrangement (tractor engine-propeller ahead of the cabin, pusher combination at the rear) was selected for several reasons, but chiefly to assure greater safety for single-engine operation. "If for any reason one-engine operation is necessary," says D. L. Roskam, aircraft division vice president, "the Skymaster stays on the center of thrust, making it safe and simple for any pilot to fly, eliminating single-engine procedures."

Cessna anticipates that the new fore-and-aft twin will achieve an all-time-high unit volume for twin-engine airplanes in general aviation. While releasing no specific first-flight performance data, the company had previously claimed that Skymaster "would out-perform anything in the low-price twin-engine field and will operate with a substantial margin of safety on either or both engines."

Skymaster will be shown publicly late this year; first deliveries will begin in 1962.

More Engineers Pursue Advanced Degrees

URBANA, ILL.—Although fewer college freshmen choose engineering as their field, the number of graduate engineers going after advanced degrees increased last year. According to a survey published by the American Society for Engineering Education in *Journal of Engineering Education*, 30,564 engineers were enrolled for master's degrees, and 6440 for doctor's in the 1959-60 school year—up 5.1 and 14.2 per cent over the previous year.

Advanced engineering degrees awarded numbered 7128 M.S. or equivalent, 786 Ph.D., increases of 37 and 32 per cent over 1956-57. Engineering Doctorates amounted to 8.1 per cent of the doctor's degrees granted in all fields during '59-60. In '58-59 this number was 7.6, and in '57-58 it was 7.2 per cent.

Undergraduate enrollment in colleges accredited by the Engineers Council for Professional Development continued to drop off, but for the first time in three years the decrease was slight. Also, freshman enrollment in the fall of '60 was up 1.2 per cent. According to Wayne E. Tolliver and Dr. Henry H. Armsby, U. S. Office of Education, "within the next year or two, total undergraduate engineering enrollments may once again show annual increases typical for this major field of study."

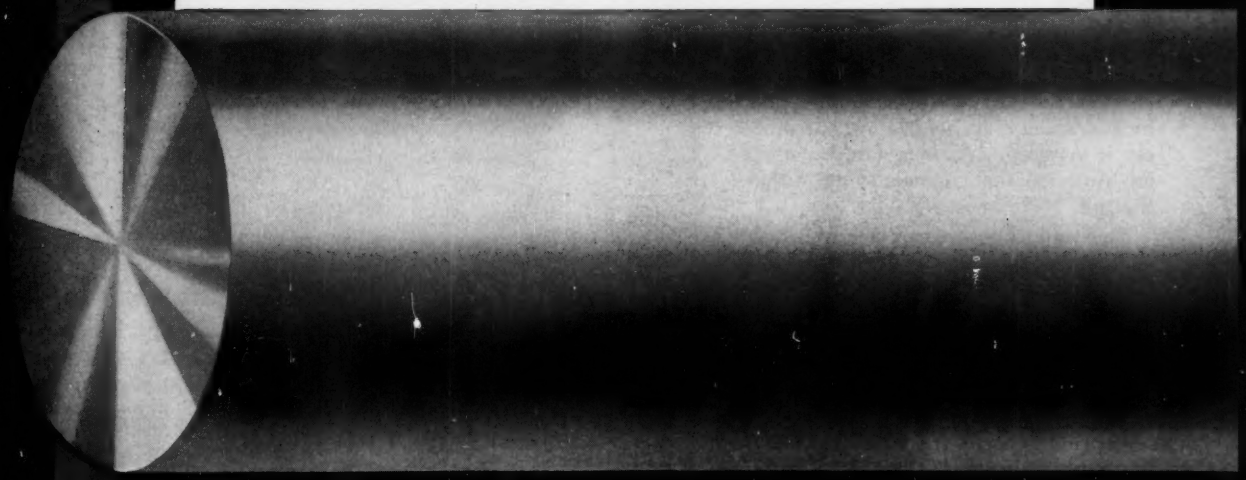
Application tested! Proved!

WHY HEAT TREAT PARTS? use e.t.d. 150

elevated temperature drawing (150,000 psi tensile)

ALLOY STEEL BARS

- **e.t.d. 150 Alloy needs no heat treating!**
- **e.t.d. 150 Alloy has 150,000 psi tensile guaranteed! (Rockwell C32 minimum)**
- **e.t.d. 150 Alloy machines better than heat treated alloy steels!**



Here are cost-reducing advantages

(1) Heat treating problems, costs (and secondary operations) are eliminated. (2) "e.t.d." 150 machines better than heat treated in-the-bar alloy steels. (3) Tool life and finish are excellent. (4) No quench cracks or distortion from heat treatment. (5) "e.t.d." 150 has exceptional strength and hardness uniformity across the bar. (6) End cost of parts is greatly reduced.

Use this coupon to request Helpful Data Bulletin 22.

La Salle STEEL CO.
1426 150th St. Hammond, Ind.

Manufacturers of STRESSPROOF®, FATIGUE-PROOF®, and a complete line of cold-finished steel bars.

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

Available from your Steel Service Center

Circle 407 on Page 19

Electric Cooling— Portable and Permanent

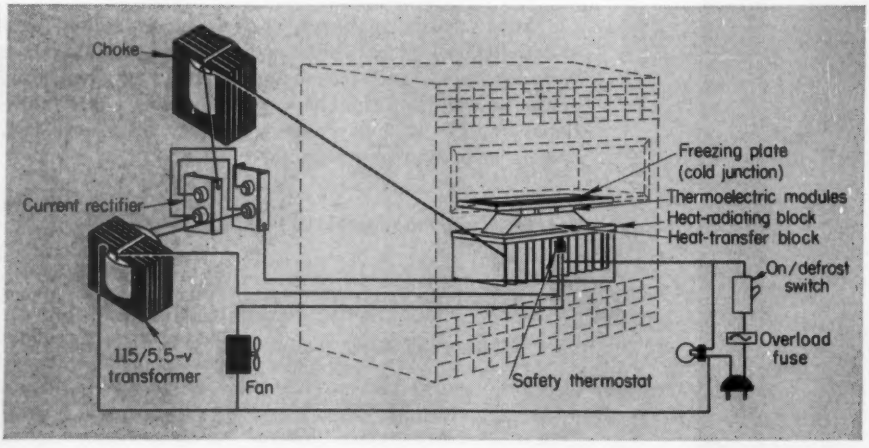
TWO of the newest thermoelectric systems unveiled are a suit that keeps the wearer comfortable when temperatures range from −40 to 135 F, and a refrigerator-freezer designed for the commercial market.

The air-conditioned suit, developed by Westinghouse Electric Corp., Pittsburgh, for the Navy, is an experimental model. Heated or cooled by electric current, it maintains an 80-F internal temperature and is completely airtight (it is made of an insulated aluminum-coated fabric). Air for breathing is supplied through a face mask connected to the side of the helmet.

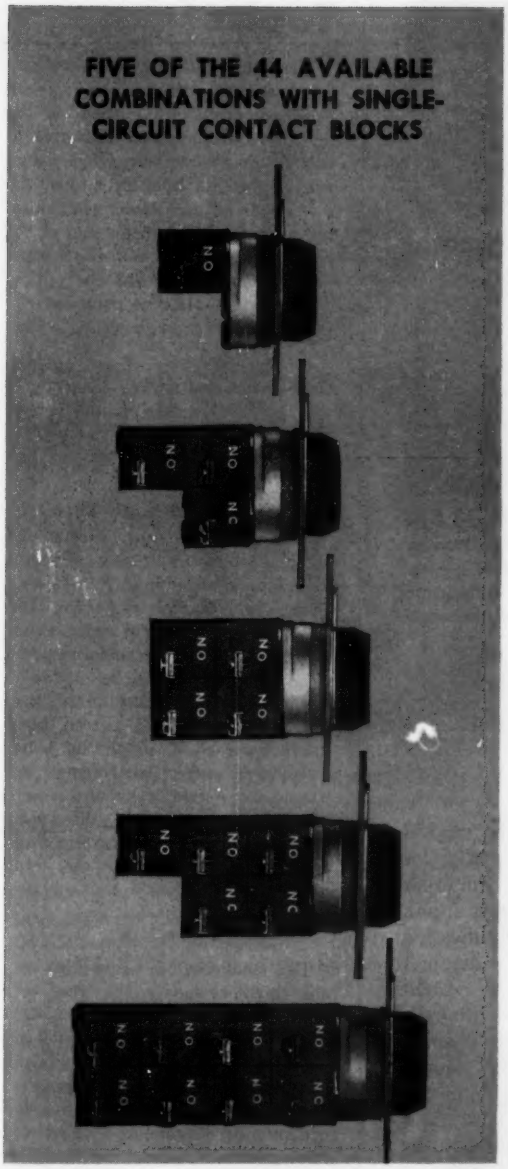
During cooling, heat from the thermocouples is removed to a hot-side heat exchanger and dumped to the atmosphere by a small fan; during heating, the process is reversed. Another fan, mounted on the same shaft, circulates air within the suit.

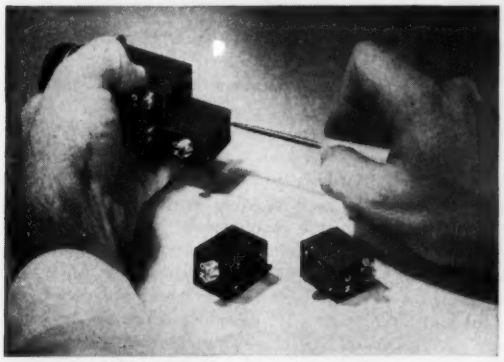
The refrigerator-freezer, 500 of which will be installed in the new Sheraton-Chicago Hotel, was developed by Norge Div. of Borg-Warner Corp., Chicago. The device uses thermocouples that have a figure of merit of three. Forerunner of a home refrigerator, the unit will probably find application in hospitals, medical centers, and boats (as well as hotels). According to Norge, in three to five years, when the figure of merit reaches ten, thermoelectric refrigerators will be practical for the home.

Test-chamber heat melts butter (left) but the man in the suit is comfortable. The experimental suit was developed to test the possibility of air-conditioned attire for military personnel. Thermoelectric pack fits on the back (above); batteries are worn on the chest, making the suit completely portable. The suit can be independent of any other power source for one hour.



No mechanical compressor is needed in the new Norge refrigerator-freezer. Cooling by thermoelectricity, the unit uses three thermoelectric modules, each consisting of eight pairs of couples. A 10-w air-circulating fan cools the hot-junction fins, and a thermostatic safety cutout switch protects the device from accidental overheating. A limiting factor in performance of the appliance is that temperature of the cooling plate never gets more than 80 F below ambient air.

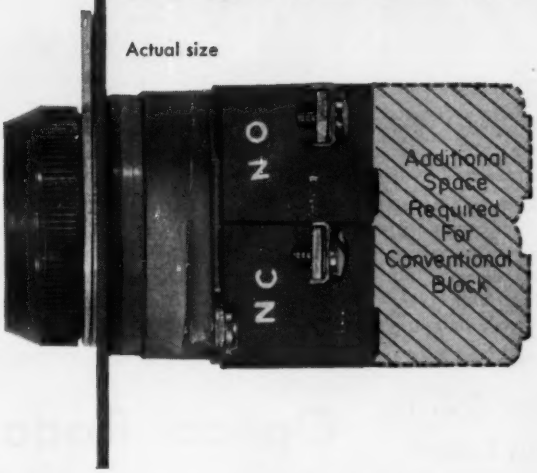




EASY INSTALLATION on a standard operator is possible because blocks are interchangeable. Two captive screws fit into internally threaded screwheads of previous unit to hold block assemblies securely.

NEW

Shallow Contact Blocks for General Electric Heavy Duty Oil-tight Push Buttons



- **BUY ONLY THE CIRCUITS YOU NEED**
- **CONTROL UP TO 8 CIRCUITS IN ANY COMBINATION OF NO-NC**
- **SAVE BACK-OF-PANEL SPACE**

It is no longer necessary to pay for unused circuits in oil-tight push buttons. And you are no longer limited to a maximum of four normally open—four normally closed circuits.

General Electric's new shallow contact block offers you the savings and flexibility of "single-circuit" design. Separate normally open and normally closed blocks are available and up to eight blocks may be mounted with a standard operator. You can buy only the circuits you need in *any* combination—even eight NO or eight NC.

Nearly one inch shorter than conventional contact blocks, the new shallow block saves important back-of-panel space. Four blocks (four separate circuits) take up no more back-of-panel depth than a conventional two-circuit block.

Shallow contact blocks are designed for use with standard General Electric oil-tight operators. Since the new block is offered in addition to G.E.'s standard block, and is interchangeable with it, you now get even greater flexibility with the G-E oil-tight push-button line.

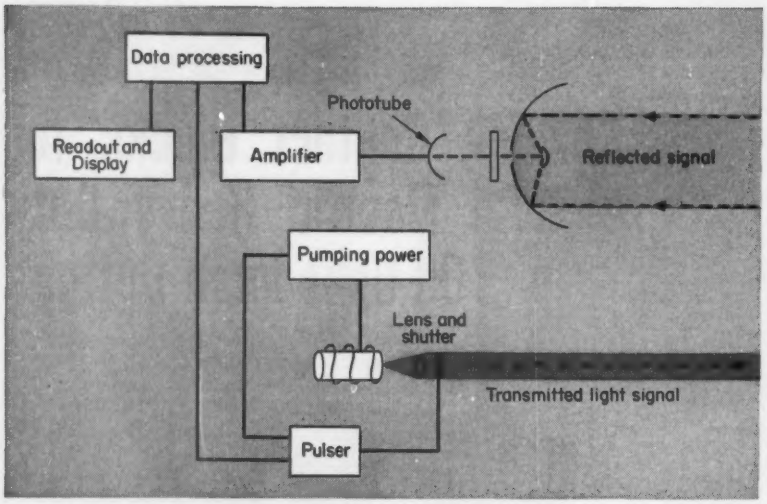
Call your nearby G-E Sales Engineer for more information, or write for publication GEA-7320 to Sect. 811-24, General Electric Co., Schenectady, N. Y.

You get **MEASURABLE ADVANTAGES**
WITH GENERAL ELECTRIC CONTROL

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 408 on Page 19



Pulser feeds pumping power to the laser (center, in spirals), generating red light that is transmitted through a lens and shutter. When the pulsed, very narrow beam strikes a target, part is reflected back to a telescope-like receiver. After being collected by a mirror, focused, and filtered, the reflected light is fed into a photo tube, creating a low-noise signal that can be processed for all the usual radar information—range, range rate, angle, and angle rate.

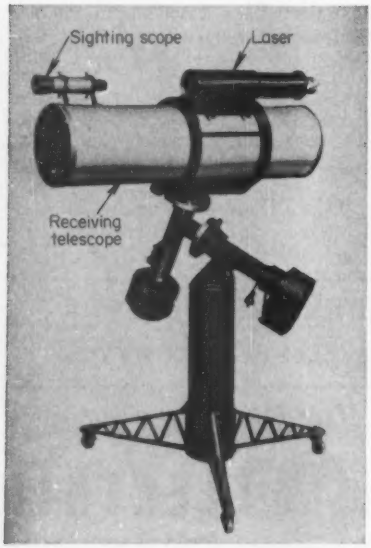
First Job for The Laser: Optical Radar

CULVER CITY, CALIF.—The much-heralded laser, a ruby-crystal that generates coherent light, is living up to predictions. Hughes Aircraft Co. has built it into a light-beam radar called Colidar (for coherent light detection and ranging). It's the first radar-like system to meet satellite requirements.

Among Colidar's features are long range, low weight, low power needs, and small size. Although several refinements have yet to be worked out, the unit has the potential for an outer-space range of hundreds of miles on very little power input.

The laser (for light amplification by stimulated emission of radiation) makes the system practical. Light generated is highly monochromatic (6943 angstroms), and the beam is very narrow. Because it's monochromatic, light reflected from the target can be directed through a narrow-band light filter, eliminating background noise.

In the attenuating atmosphere of Earth, Colidar will discriminate between 10-ft wide targets, side-by-side, at a range of 10,000 yd. In space, a receiver located on one vehicle could pick up signals from another at a distance of 100,000 miles.



Flashing coherent light beams instead of microwaves, a new kind of radar will provide eyes for spacecraft. Small and lightweight, the Hughes' Colidar system has an in-space range of hundreds of miles, yet requires very little input power.

Topics

The fastest gun in grade school can be determined accurately by a toy pistol equipped with a timer in the butt, a recent invention belonging to Kilgore Inc., Westerville, Ohio. Before putting the gun into his holster, the user winds an escapement mechanism by turning a wheel in the end of the pistol grip. The clockwork starts when he puts his hand around the grip to draw; it stops when he pulls the trigger. Elapsed time is shown on a dial.

• • •

Air-conditioned movies — outdoors — will be offered soon by a drive-in theater in southern California. Big units will cool the air around customers' cars.

• • •

Souping up a rocket could be as easy as bolting on extra engines, according to an idea advanced by Aerojet-General Corp. The segmented solid rocket principle is based on a solid rocket engine capable of producing a standard amount of thrust, which is to be used as a basic unit. When more thrust than one engine provides is needed, additional units could simply be bolted together, instead of designing a new powerplant. Aerojet says that this technique has already been successfully demonstrated for the Air Force with an eye to developing a rocket that could be shipped in sections to the launching site.

• • •

Two synthetics are better than one, and almost as good as the other, in a new tire developed by Seiberling Rubber Co. The tire's two inner plies are nylon, and the outer plies are rayon. Tests show that it is more resistant to impact breaks than a rayon tire, but not quite as resistant as a nylon one. Price is about midway between tires made of either one material or the other.

• • •

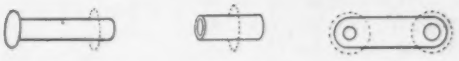
A computer out-designed engineers, and its plans are being used to build a chemical plant for Shell Oil Co. The computer was fed data on basic chemicals and reactions needed; variables such as cost, temperature, and pressure requirements; safety factors; air-pollution limits; and local zoning laws. In 16 hours it figured out 16,000 possible factory designs and selected the one that would produce the most for the least money. A team of engineers had worked out three designs in a year, each of which would have cost about half a million dollars more than the machine's. The machine logic system was devised by Richard R. Hughes—a Shell engineer—aided by mathematicians and chemical experts.

FAR LESS STRESS IN LXS

THE CHAIN WITH NO "STRESS RAISERS"!
Link-Belt LXS brings long-term economy and efficiency to the most punishing drive and conveying jobs. With its "FULL-ROUND" design, LXS has no stress concentration points . . . none of the sharp corners which frequently shorten the life of many ordinary chains.

LXS is available with straight or offset sidebars. For details, contact your nearest Link-Belt office. (See CHAINS in the yellow pages of your phone book.) Ask for our new, comprehensive Catalog 1050.

They're all of "FULL-ROUND" design



PINS BUSHINGS SIDEBARS

"FULL-ROUND" design eliminates traditional stress concentration points in Link-Belt LXS . . . provides maximum live bearing area between pins and bushings. Result: stress is distributed evenly.

Other LXS long-life features include controlled press fits plus use of selected steels and controlled hardening of all parts. All this contributes to greater uniformity, greater endurance.

LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,062

Circle 409 on Page 19

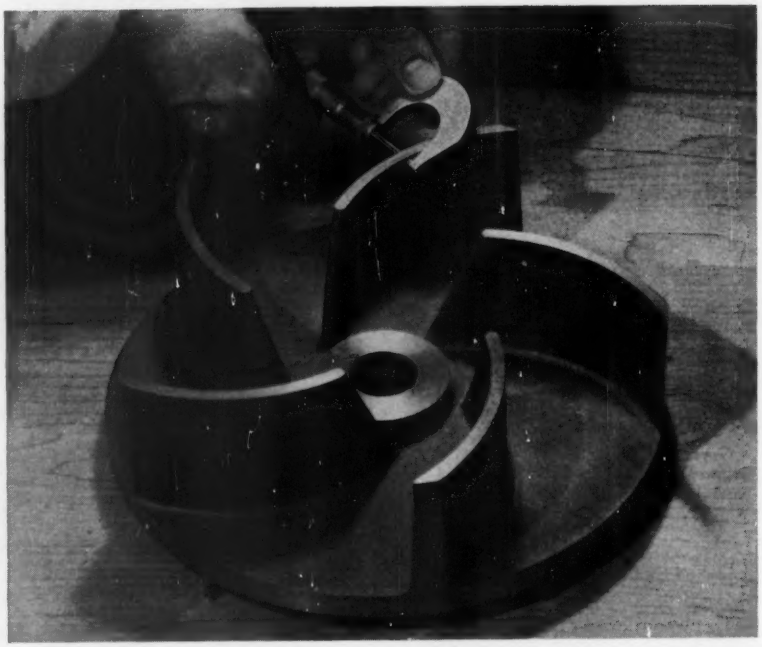
Titanium Castings Are Mass-Produced by New Process

NEW YORK—A new method of casting titanium, with greatly reduced die costs, promises parts such as pump housings, impellers, valve bodies, and fittings on a production-line basis. Impel casting, developed by Titanium Metals Corp. of America, uses permanent molds—probably good for 100 or more parts—instead of graphite molds, which are limited to 10 or 12 parts or—more often—one part per die.

The Impel casting process depends upon titanium's excellent fluidity to produce high-strength, accurate, intricate, and stable parts. The titanium is in the form of an electrode, double melted, and the molten metal is "impelled" into the die cavity.

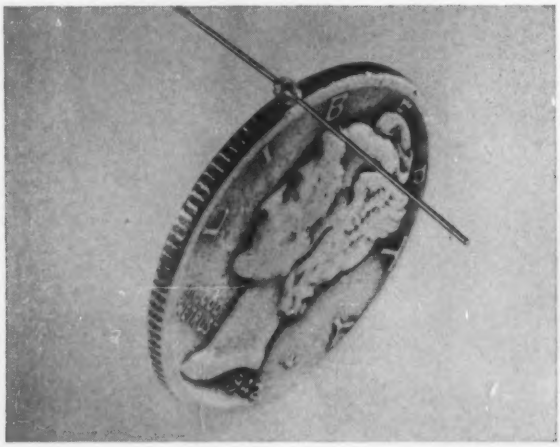
Titanium's shrinkage rate, 0.005 in. per in., makes timing a critical factor in feeding the metal into the die cavity and pulling the cores before it freezes.

To date, TMCA has produced 40 castings per mold, but believes that at least 100 can be made. On very large production runs, where several dies are likely to wear out, the dies also can be cast for added savings.

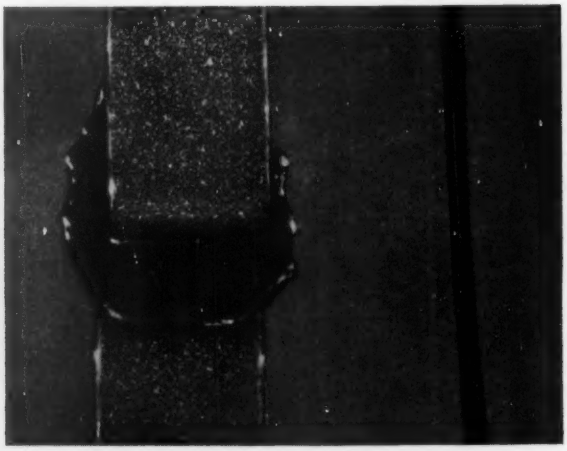


A 9-in., 12-lb impeller is the first part produced commercially by the new Impel casting process for titanium. Mold cost was absorbed by the first nine impellers made by the new method, and the cast parts are less expensive than welded titanium impellers now in use. Present equipment for permanent-mold casting limits parts to 12 lb and boundaries of 5 by 10 by 24 in. However, titanium castings up to 148 lb, and 72 by 36 by 24 in. have been made in graphite molds.

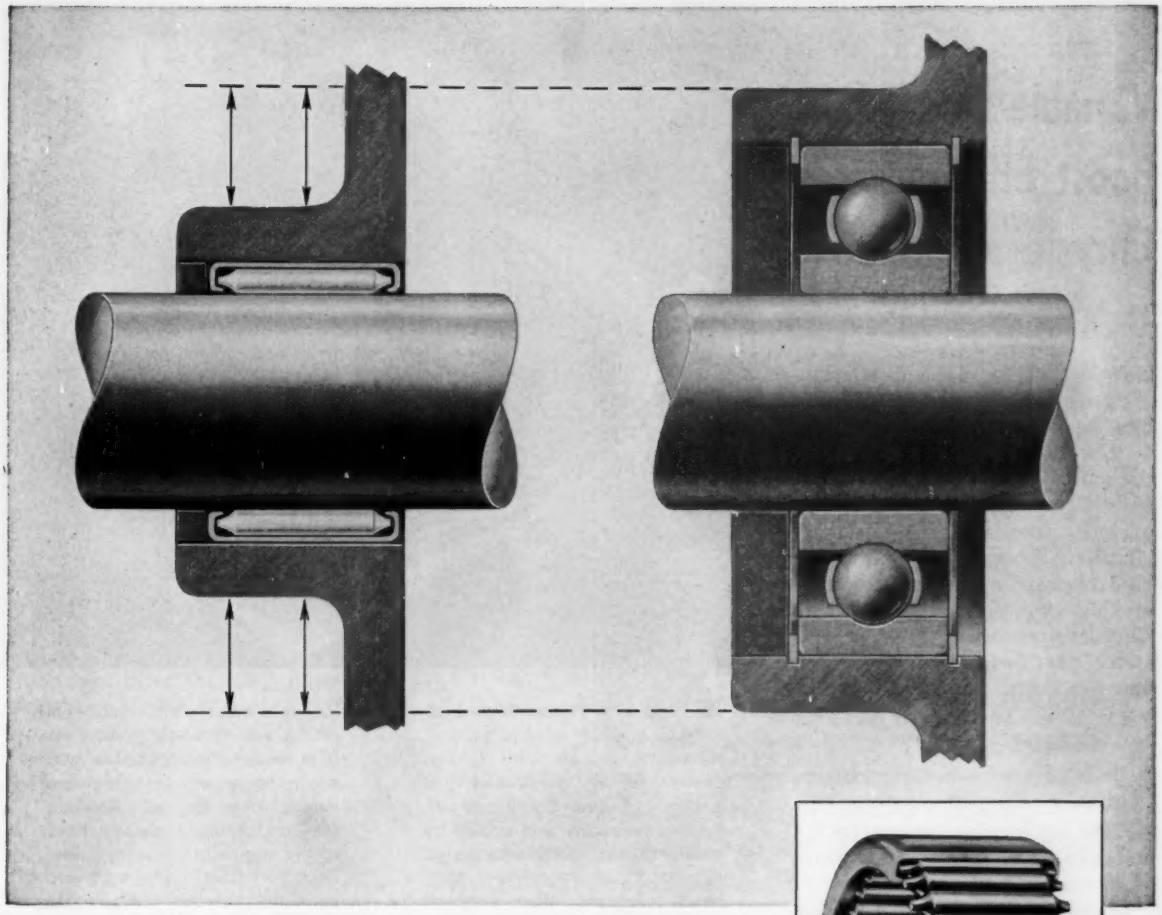
Diminutive Duo of Diodes



Smaller than the head of a pin, the newest glass diodes developed by Texas Instruments Inc., Dallas, measure only 0.040 in. diam by 0.060 in. long. The tiny components provide volume reductions of 50:1 over conventional diodes with similar characteristics. Expected to find wide use in gates, logic circuits, and high-speed switches, one diode consists of two round leads, a glass case, and a single diffused silicon mesa wafer whose surface has been oxide passivated for optimum stability and reliability.



Surface-passivation techniques paved the way for development of this tiny diode by MicroSemiconductor Corp., Culver City, Calif. The device, (compared to a hair, above) measures 0.075 in. by 0.030 in. (maximum dimensions), does not require encapsulation. MSC reports success in stabilizing erratic surface properties by using unique methods of altering oxides and bonding them to the crystal surface. This technique eliminates bulky packaging and does away with most of the factors that previously limited reliability.

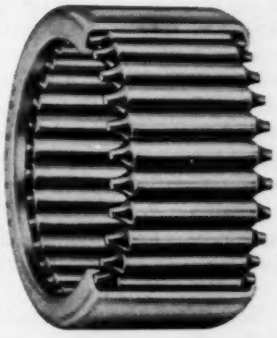


Designed for Compactness... Torrington Needle Bearings

Simpler, more compact design is possible wherever Torrington Needle Bearings are put to work in eliminating friction problems.

These outstanding bearings offer a higher radial load capacity than any other bearing of comparable size. They are more compact, lighter in weight, and are lower in unit cost. The full complement of small-diameter precision rollers insures exceptional antifriction performance and long, maintenance-free service life. The turned-in lips on the outer shell guarantee positive roller retention. Installation and assembly are fast, simple, economical.

The unmatched design and production advantages of Torrington Needle Bearings have been proved in applications ranging from office machines to automobiles, washing machines to earth-moving machinery. Give *your* product the benefit of our antifriction know-how. Write or call Torrington—maker of every basic type of antifriction bearing.



TORRINGTON NEEDLE BEARINGS FEATURE:

- Full complement of retained rollers
- Unequalled radial load capacity
- Low coefficient of starting and running friction
- Low unit cost
- Long service life
- Compactness and light weight
- Run directly on hardened shafts
- Permit use of larger and stiffer shafts

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY Torrington, Conn. • South Bend 21, Indiana

Circle 410 on Page 19

Variable Nozzles Boost Efficiency of Chrysler's Turbine

NEW YORK—One of the few remaining problems in automotive gas-turbine development is reported solved at Chrysler Corp. Working with the company's 140-hp CR2A engine, powerplant engineers have perfected a variable-nozzle mechanism which effectively changes pitch of the turbine blades during acceleration or braking. George J. Huebner Jr., Chrysler's executive engineer, research, says the variable-nozzle system has licked three problems:

- Excessive low-speed, part-load fuel consumption
- Lack of engine-braking characteristics
- Time lag between pressure on the accelerator and full-power response of the engine.

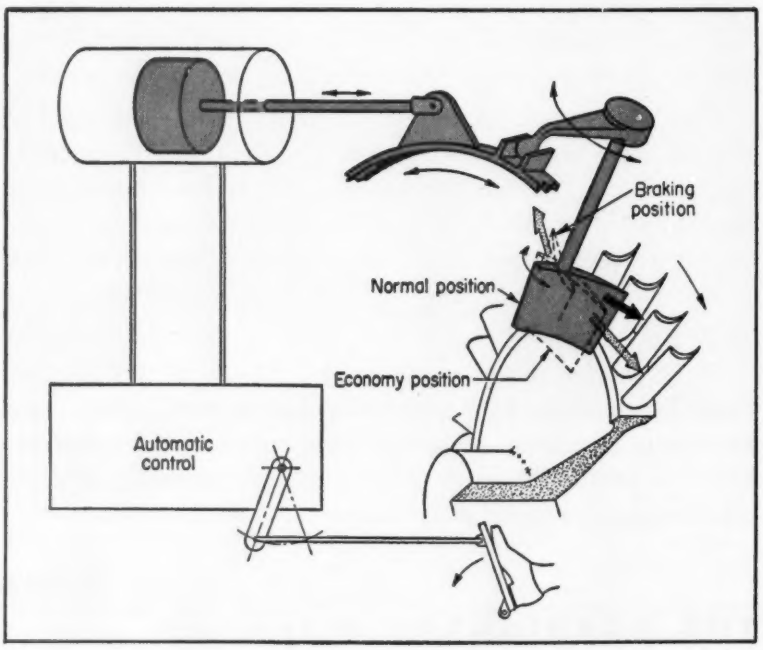
Chrysler's engine is a free-turbine powerplant. The first turbine wheel produces power for compressor, pumps, and other components. Power from the second wheel is transmitted through a single-stage helical reduction gear to the drive shaft, and to the rear wheels of the automobile.

Gas flow through the engine reaches the second turbine wheel after passing through 23 vanes, arranged in a circle, which direct the gas at the turbine blades. In the usual engine, these vanes, which form the nozzle passages, have been fixed in one direction only, and the gas flow through the nozzle is constant whether the car is idling, accelerating, or going down-hill with the engine idling. As a result, turbines have been plagued by a lack of efficiency under the wide range of operating conditions required for surface vehicles—fuel consumption has been dictated by the amount of combustion gas pouring uncontrolled between the fixed nozzle vanes.

Designers at Chrysler found that by varying the pitch of the vanes, higher cycle temperatures could be

Mounted in a Plymouth testbed, Chrysler's CR2A engine (above) represents a near-final configuration for an automotive gas turbine. Engine housing is insulated internally and cooled by ambient air, compressor-outlet air, and engine-exhaust gas. Heat insulation also acts as sound insulation. An intake filter-silencer, mounted ahead of the compressor, prevents dirt accumulation and reduces noise at the compressor inlet.

Variable nozzles mounted ahead of the second-stage (power) turbine, automatically change pitch according to gas generator and vehicle speed (below). Acceleration and braking characteristics of the engine are thus optimized. Because nozzle blades vary pitch as a function of gas-generator speed, turbine-inlet temperature is sustained at near design-point value during part-load. This increases thermodynamic efficiency of the engine, ups fuel economy.



maintained during all phases of operation, and that by almost reversing the vanes, a desired braking effect could be produced on the wheels of the car.

According to Huebner, almost three years were required to translate the idea of the variable nozzles into reality. Each of the 23 nozzles is actually an airfoil-shaped blade mounted on the end of a shaft. A crank with a ball-shaped end is mounted at the other extremity of the shaft. The ball rides in a ring groove. The entire mechanism is somewhat similar to a ball bearing with a slotted outer race. There are 23 shafts and 23 ball-ends set in the individual grooves. The ring rotates a few degrees, actuated by a rod and a lever from an automatic control piston, and this swings the shafts, turning the blades as much as 100 degrees.

Extended tests have proved the effectiveness of the mechanism, and it promises more reliable, quieter gas-turbine engines because maximum engine torque can be obtained at lower speeds. However, large-scale production of the engine for passenger-car use is not in the near future, says Huebner. (Rumor in Detroit has it that Chrysler will introduce a turbine-powered model in 1964.) Chrysler has indicated, however, that it will offer a limited number of the turbine powerplants for sale "on a negotiated basis to potential users for study and evaluation in experimental applications."

Following is a list of significant CR2A specifications:

Powerplant Design-Point Characteristics	
Output power (hp)	140
Fuel consumption (lb/hp-hr)	0.51
Compressor air flow (lb/sec)	2.2
Turbine inlet temp (F)	1700
Exhaust temp, full power (F)	400
Gas-generator speed (rpm)	44,610
Power-turbine speed (rpm)	45,730

Component Design-Point Characteristics	
Compressor pressure ratio	4:1
Compressor efficiency (per cent)	80
Turbine efficiency (per cent)	
First stage	87
Second stage	84
Burner efficiency (per cent)	95
Regenerator effectiveness (per cent)	90
Regenerator leakage (per cent)	4
Accessory load (hp)	2

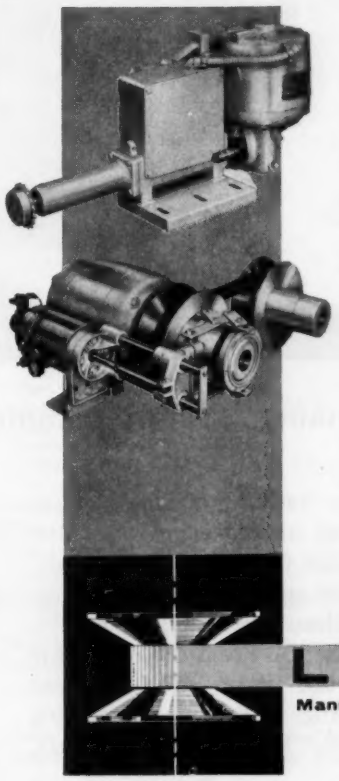
General Engine Characteristics	
Weight (lb)	450
Length (in.)	36
Width (in.)	35
Height (in.)	27

NOW...
BOTH HORIZONTAL
AND VERTICAL
LEWELLEN
VARIABLE SPEED DRIVES

Here are both horizontal and vertical variable speed drives. Each is an assembly of standard components — a motor, LEWELLEN Combination Pulleys, and the horizontal or vertical Countershaft.

The horizontal drive assembles either right hand or left hand. Both the horizontal and vertical drives mount at floor or ceiling.

Accessories may include the mechanical Indicator, or the Electric Tachometer and Electric Remote Control, as shown.



A bridge circuit controller dials all speed settings by equipping the Electric Control unit with a potentiometer.

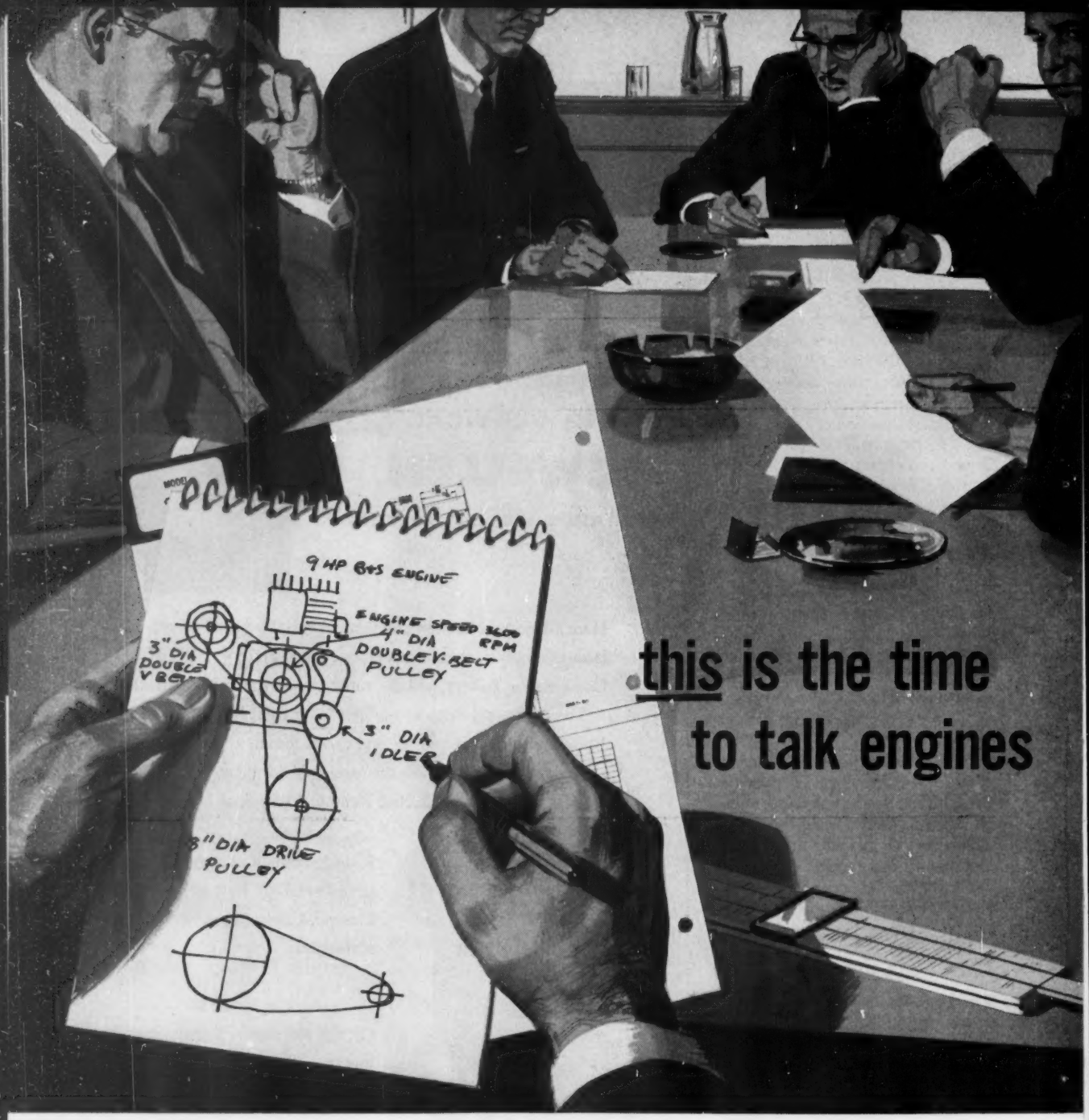
Or, the Pneumatic Regulator automates the operation by connecting with process instruments.

Here are accessories for readily using the flexibility of variable speeds — for using LEWELLEN Variable Speed Drives as you choose.

Write for Catalog 70

LEWELLEN
Manufacturing Company, Columbus, Indiana
Distributors in all Industrial Areas

Circle 411 on Page 19

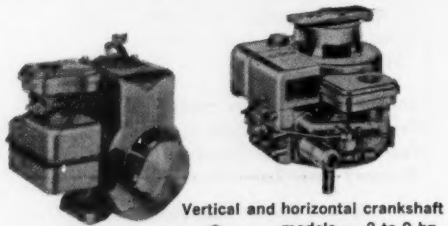


this is the time to talk engines

when you start your thinking . . . start planning with Briggs & Stratton

NEW PRODUCT IDEAS find an earlier "meeting of minds" when you plan gasoline-powered equipment around engine specifications from Briggs & Stratton. Let our Consulting Engineering Service give you detailed information on models . . . even help with those knotty special power problems. Get facts, too, on new Briggs & Stratton features such as "Oil-Foam No-Spill" Air Cleaner, "Shock-Free" Windup Starter, "Pulsa-Jet" Carburetor and other features. Write or phone Hugh S. Brown, Engineering Vice President, Briggs & Stratton Corp., Milwaukee 1, Wisconsin. (Phone LOcust 2-5000.)

Circle 412 on Page 19



Vertical and horizontal crankshaft models — 2 to 9 hp

4 CYCLE BRIGGS & STRATTON GASOLINE ENGINES ®

Most respected name in power

Reader Information Service

SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

Aircraft, Edit. 24
Alloys, high-temperature, Adv. 43
Aluminum and alloys, Adv. 109, 241
Automobiles, Edit. 24

Balls, Adv. 248
Beams, Edit. 173
Bearings,
  ball, Adv. 21, 55, 56, 57, 58, 74
  miniature, Adv. 74
  needle, Adv. 13
  roller, Adv. 21
Bellows, Adv. 261
Belts, transmission, Adv. 35, 84, 87
Blowers, Adv. 37, 38, 77
Books, Edit. 243
Brakes, Edit. 192; Adv. 212
Brass, (see Copper and alloys)
Brazing alloys, Adv. 106
Bronze (see Copper and alloys)

Cams, Edit. 202
Caps, Adv. 213
Casters, Edit. 228
Castings,
  die, Adv. 86, 259
  investment, Adv. 210
  iron, Edit. 162; Adv. 201
  meehanite, Adv. 230
  nonferrous, Adv. 220
Chain,
  conveyor, Adv. 11, 29
  transmission, Adv. 11, 29, 80, 191
Clamps, Adv. 192
Clutches, Adv. 99, 185, 238
Coatings,
  decorative, Adv. 122, 123
  protective, Adv. 122, 123, 262
Computers, Edit. 22, 188
Connectors, electric, Edit. 226; Adv. 62, 116, 117
Control systems,
  hydraulic, Edit. 158
  mechanical, Adv. 53
Controls,
  electric, Adv. 214
  hydraulic, Adv. 1, 206
  mechanical, Adv. 92
  pneumatic, Adv. 217
Converters, Adv. 232
Copper and alloys, Adv. 102, 106
Couplings,
  fluid flow, Edit. 146
  shaft, Edit. 256, 258; Adv. 187, 215, 259, 264
Cylinders,
  hydraulic, Adv. 89, 268
  pneumatic, Adv. 70, 89, 214

Drafting equipment, Edit. 234, 238; Adv. 50, 63, 65, 125, 207, 253, 262
Drives, adjustable speed, Adv. 15, 119, 193, 247
Drives, right angle, Adv. 42

Electric equipment (see specific type)
Electronic equipment, Edit. 24; Adv. 44, 45, 191
Enclosures, Adv. 222
Engineering department (see Management or Drafting)
Engineering and research, Edit. 130
Engines, Edit. 26, 187; Adv. 16

Facilities, general, Adv. 261
Fans, Adv. 77
Fasteners,
  bolts, studs, screws, Adv. 78, 114, 115, 118, 257, 260, 262, 266, inside back cover
  insert, Adv. 190
  nuts, Edit. 202; Adv. 98, 118, 221
  pin, Adv. 124, 229
  quick operating, Adv. 94, 200
  retaining rings, Edit. 207; Adv. 51
  rivet, Adv. 218
Feeders, parts, Adv. 233
Fiber, Adv. 111
Filters, Adv. 54
Finishes (see Coatings)
Fittings, pipe, tube, and hose, Edit. 212, 254; Adv. 61, 81, 90, 243
Forgings, Adv. 120, 216
Forming, Adv. 256
Friction materials, Adv. 110, 186

Gages (see also Instruments), pressure, Adv. 187
Gaskets, Adv. 79, 267
Gears, Adv. 82, 236, 264, 267
Generators, electric, Adv. 199
Glass, Adv. 237
Governors, Edit. 136, 257; Adv. 220

Heaters, Adv. 231, 258
Hose, nonmetallic, Adv. 228
Hydraulic equipment (see specific type)
Hydraulic fluid, Edit. 191

Instruments, Edit. 30, 135, 155, 236; Adv. 72, 245, 263, 266

Knobs, Edit. 226; Adv. 262

Lighting, Adv. 219
Lubrication,
  equipment, Adv. 40, 41
  systems, Adv. 107

Materials, Adv. 97
Materials handling equipment, Edit. 152
Meetings, Edit. 39
Metals (see specific type)
Metalworking equipment, Adv. 244
Motors (electric),
  fractional and integral hp, Adv. 73, 96, 126, 127, 206, 260
  gearmotors, Adv. 263
  subfractional hp, Edit. 224; Adv. 73, 198, 216, 223

Nickel and alloys, Adv. 59

Optical wedge, Edit. 172
Oscilloscopes, Edit. 240

Packings, Adv. 52, 85, 234, 260

MACHINE DESIGN is indexed in the Applied Science & Technology Index and the Engineering Index, available in libraries, generally. Microfilm copies are available from University Microfilms, 313 N. First St., Ann Arbor, Mich.

Plastics, Edit. 190, 219; Adv. 85, 203, 239, 242
laminates, Adv. 100, 101, 111, 255
molding, Adv. 31, 203, 239
Plugs, Adv. 213
Pneumatic equipment (see specific type)
Potentiometers, Edit. 214
Powder metallurgy, Adv. 261
Pumps,
hydraulic, Adv. 48, 68, 108, 188, 192, 225, 226, 227
pneumatic, Adv. 48
Pushbuttons, Edit. 202; Adv. 9

Recorders, Edit. 234; Adv. 72
Reducers, speed, Adv. 64, 88, 185, 189, 251
Regulators,
flow, Adv. 222
pressure, Edit. 138; Adv. 103
Relays, Edit. 216, 225; Adv. 60, 66, 67, 91, 210, 245
Resistors, Adv. 33, 240
Rotary joints, Adv. 260, 265
Rubber, Adv. 84, 265

Screws, power, Adv. 71
Seals, Adv. 259, 267
Shafts, flexible, Adv. 224
Shims, Adv. 121
Silicones, Adv. 2, 49
Slider-crank mechanism, Edit. 159
Solenoids, Edit. 220; Adv. 200
Spiroid gearing, Edit. 165
Springs, Edit. 141; Adv. 265
Steel, Adv. 5, 7, 46, 47, 104, 105, 208, 209, back cover
strip, Adv. 47
Switches, Edit. 204, 218; Adv. inside front cover, 69, 83, 183, 195
Systems, hydraulic, Edit. 252

Terminals, Adv. 117
Thermostats, Edit. 227; Adv. 112
Timers, Adv. 197, 266
Tin and alloys, Adv. 189
Transducers, Edit. 252
Transformers, Edit. 202
Transistors, Edit. 206, 228
Transmissions, adjustable speed, Edit. 157, 206, 254; Adv. 211, 246
Tubing, Adv. 205, 242, 243, back cover

Universal joints, Adv. 218

Valves,
hydraulic, Adv. 1, 75, 76, 113, 225, 252, 263
pneumatic, Edit. 202, 231; Adv. inside front cover, 75, 76, 95, 113, 217, 252

Washers, Adv. 264
Ways, Adv. 196
Wheels, Adv. 37, 38
Wire and wire products, Adv. 93, 235, 254

Zinc and alloys, Adv. 128

USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature

BY ITEM NUMBERS

HELPFUL LITERATURE—descriptions start on page 194

	ITEM NUMBER
Self-Cleaning Strainers	701
Pressure Transducers	702
Rotary-Armature Relays	703
Electronic Equipment	704
Wirewound Resistors	705
Control, Indicating Components	706
Circuit-Breaker Load Centers	707
Flexible Couplings	708
Welding Alloy Chart	709
Steel Selection	710
Pipe and Tubing Measurement	711
Silicone Compounds	712
Force Transducer	713
Subminiature Connectors	714
Industrial Coated Fabrics	715
Electric Motors	716
Servo Systems	717
Pushbutton Station	718
Electric Motor Components	719
Weight Sensing	720
Ball Valves	721
Rubber Products	722
Welding Stainless Steel	723
Switch Selection	724
Flowmeter Kits	725
Kralastic ABS Plastics	726
Pipe Connections	727
Control Knobs	728
Friction Materials	729
Positioning Control	730
Caster Selection	731
Hydraulic Fittings	732
Nonmetallic Alloys	733
Plastic Products	734
Thermal Insulation	735
Thyratrons	736
Conveyor-Belt Selection	737
Molded Plastics	738
Regulators, Control Valves	739
Acceleration Switches	740
Computers and Accessories	741
Semiconductor Bases	742
Accelerometers	743
Pushbutton Stations	744

NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 202

	ITEM NUMBER
Lighted Pushbutton	745
Transistor Transformers	746
Vinyl Magnetic Strip	747
Two-Way Lock Nut	748
Air Valves	749
Adjustable Cam Assemblies	750
Miniature Switch	751
Servo Motor	752
Germanium-Alloy Transistors	753
Two-Speed Transmission	754
Retaining Ring	755
Universal Tension Latch	756
Silicon Readout Photocells	757
O-Ring Seal Fittings	758
O-Ring Knob	759
Trimmer Potentiometer	760
Bar Switch-Light	761
Precision Relay	762
Spray Nozzle	763
Pushbutton Switches	764
Polycarbonate Resin	765
Panel-Wireway System	766
Laminated Solenoids	767
Pinpoint Lens Holder	768
Visual Indicators	769
Copper-Clad Laminate	770
Custom Harnesses	771
Retaining Spring Clips	772
Miniature Motor	773
Multiple-Unit Valves	774
Mercury-Wetted Contact Relay	775
Ball Knobs	776
Printed-Circuit Connectors	777
Angle and Y-Strainers	778
Miniature Thermostat	779
Epitaxial Mesa Transistors	780
Swivel-Lock Caster	781
Silicone Plotting Material	782
Control Valves	783
Bearing Take-Up Frames	784
Reservoir Pen	785
Miniature Vacuum Recorder	786
Ceramic Cement	787
Torque Gages	788
Dial Indicator	789
Tracing Vellum	790
Dual-Trace Oscilloscopes	791

MACHINE DESIGN
March 16, 1961

Circle item number for information on products advertised or described or copies of literature.

251	421	451	481	511	541	571	601	631	661	691	721	751	781	811	841
252	422	452	482	512	542	572	602	632	662	692	722	752	782	812	842
253	423	453	483	513	543	573	603	633	663	693	723	753	783	813	843
254	424	454	484	514	544	574	604	634	664	694	724	754	784	814	844
255	425	455	485	515	545	575	605	635	665	695	725	755	785	815	845
256	426	456	486	516	546	576	606	636	666	696	726	756	786	816	846
257	427	457	487	517	547	577	607	637	667	697	727	757	787	817	847
258	428	458	488	518	548	578	608	638	668	698	728	758	788	818	848
259	429	459	489	519	549	579	609	639	669	699	729	759	789	819	849
260	430	460	490	520	550	580	610	640	670	700	730	760	790	820	850
401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after May 16, 1961

MACHINE DESIGN
March 16, 1961

Circle item number for information on products advertised or described or copies of literature.

251	421	451	481	511	541	571	601	631	661	691	721	751	781	811	841
252	422	452	482	512	542	572	602	632	662	692	722	752	782	812	842
253	423	453	483	513	543	573	603	633	663	693	723	753	783	813	843
254	424	454	484	514	544	574	604	634	664	694	724	754	784	814	844
255	425	455	485	515	545	575	605	635	665	695	725	755	785	815	845
256	426	456	486	516	546	576	606	636	666	696	726	756	786	816	846
257	427	457	487	517	547	577	607	637	667	697	727	757	787	817	847
258	428	458	488	518	548	578	608	638	668	698	728	758	788	818	848
259	429	459	489	519	549	579	609	639	669	699	729	759	789	819	849
260	430	460	490	520	550	580	610	640	670	700	730	760	790	820	850
401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after May 16, 1961

MACHINE DESIGN
March 16, 1961

Circle item number for information on products advertised or described or copies of literature.

251	421	451	481	511	541	571	601	631	661	691	721	751	781	811	841
252	422	452	482	512	542	572	602	632	662	692	722	752	782	812	842
253	423	453	483	513	543	573	603	633	663	693	723	753	783	813	843
254	424	454	484	514	544	574	604	634	664	694	724	754	784	814	844
255	425	455	485	515	545	575	605	635	665	695	725	755	785	815	845
256	426	456	486	516	546	576	606	636	666	696	726	756	786	816	846
257	427	457	487	517	547	577	607	637	667	697	727	757	787	817	847
258	428	458	488	518	548	578	608	638	668	698	728	758	788	818	848
259	429	459	489	519	549	579	609	639	669	699	729	759	789	819	849
260	430	460	490	520	550	580	610	640	670	700	730	760	790	820	850
401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after May 16, 1961

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY MAIL
No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY MAIL
No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

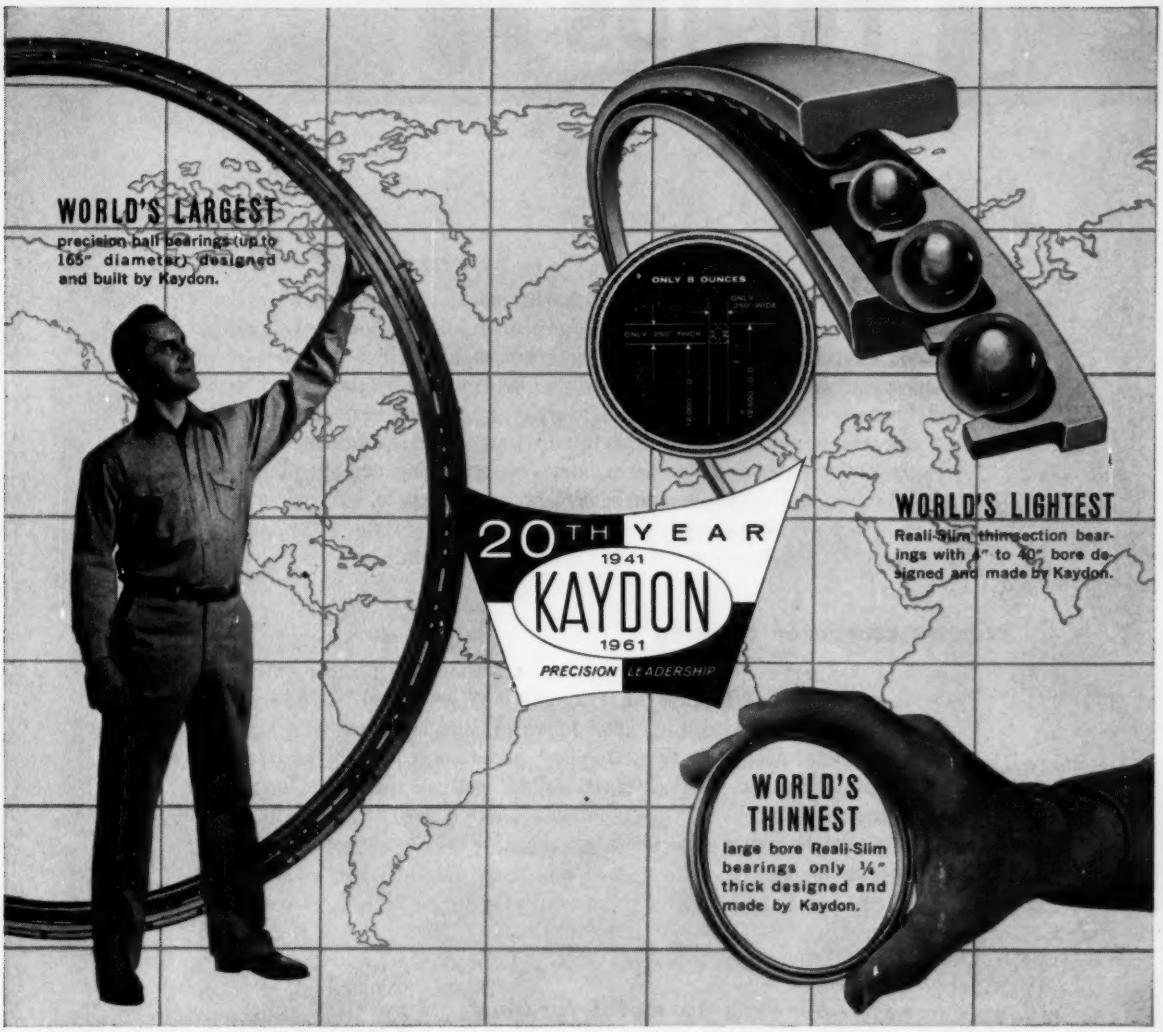
FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY MAIL
No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.


WORLD'S LARGEST
precision ball bearings (up to 165" diameter) designed and built by Kaydon.
ONLY 8 OUNCES
20TH YEAR
1941
KAYDON
1961
PRECISION LEADERSHIP
WORLD'S LIGHTEST
Reali-Slim thin-section bearings with 4" to 40" bore designed and made by Kaydon.
WORLD'S THINNEST
large bore Reali-Slim bearings only ¼" thick designed and made by Kaydon.

Our specialty . . . solving the world's toughest bearing problems

When stock bearings "won't do"... KAYDON special bearings "will"

Standard bearings often aren't adequate when you run up against a combination of limitations involving bearing capacity, size, weight, configuration, material and price.

Solve these problems with Kaydon special bearings—specifically designed and precision-manufactured to do extraordinary jobs.

Kaydon special bearings offer you wide opportunities for compact design that may reduce the size of the equipment you need — providing substantial savings.

Kaydon builds your special bearings with close-tolerance precision, exceptional thrust or radial capacity . . . out of special metals or materials.

Don't penalize performance, or rule out new concepts in design, with stock bearings that "won't do." Call on Kaydon's long experience in design of special bearings that *will* solve your toughest problem.

Available! Reali-Slim type "CP" bearings off-the-shelf in 90 sizes with Conrad deep-groove, ball-radial construction . . . and new one-piece snapover bronze separator in 4" to 12" bore — ¼" to 1" width and cross section.

K-611

THE KAYDON ENGINEERING CORP.

• MUSKEGON, MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller • Roller Radial • Needle Roller • Ball Radial • Ball Thrust • Four-Point Contact Bearings

World's highest capacity, lowest cost needle bearings (22 sizes available).

NEWS TRENDS

opportunities in orbit

The time is ripe for private enterprise to move into space—and make a profit—according to Robert E. Gross, chairman of the board of Lockheed Aircraft Corp. Mr. Gross feels that skill and salesmanship, as well as capital, possessed by private industry should be used to develop the space frontier, and he proposes that an industrial team of companies be formed to enter the commercial satellite field. This group would develop satellites, ground-support equipment, launching areas, and data-processing devices; place satellites in orbit; and maintain and replenish them in space.

campus computer crusade

To show college students that computers are more than super calculating machines, a series of lectures on "Computer Appreciation" is being given at the University of Michigan. The topics of four lecturers, who are computer specialists, deal with the machines' performance of jobs such as language translation and medical diagnosis, as well as their intelligence, inventiveness, and decision-making abilities. The series is sponsored by U-M's Ford Foundation-supported Project on the Use of Computers in Engineering Education.

a 'current' approach to metal forming

Forming high-strength metals—stainless steel and aluminum alloys—by electrical discharge will be studied by Republic Aviation Corp. for NASA. One of two basic methods to be evaluated uses shock waves created in a liquid medium to deform the workpiece. In the other process, called inductive-repulsion forming, an insulated induction coil is placed close to the workpiece; during the electrical discharge, opposing currents in the coil and the metal produce a magnetic force which repels and deforms the metal away from the coil.

solid-state sufficiency

A computer that is part of a new General Electric automatic-monitoring system does everything but the manual labor of mounting and dismounting its input and output tapes. It knows when a tape change is needed and types instructions to the human operator. A typical use of the system, appropriately named SMART, is in support of experiments at GE's Atomic Power Equipment Dept. in San Jose, Calif. At a location 30 miles away, data from experiments are recorded on punched paper tape, sent to the computer via telephone lines, and interpreted. Information needed to continue experiments is returned within a few hours. Cost-conscious, the SMART computer keeps track of time spent on each problem and prepares bills for its services.

a case for Simon Legree?

A happy employee is not necessarily the most productive employee, and executives trying to keep their subordinates content have become too "soft-boiled." These two items of information were reported recently in *Industrial Relations News*, a publication for the industrial-relations field. Personal persuasion and competitive stimuli—which may cause anxiety—are advocated as methods to increase productivity. The goal of a human-relations program is to develop employees who function at full capacity, are internally committed to their work, and have a deep sense of responsibility toward the company. Achieving this goal, says IRN, "sometimes requires forceful action that could create a degree of initial resentment on the part of employees."

NASA backs ion-rocket study

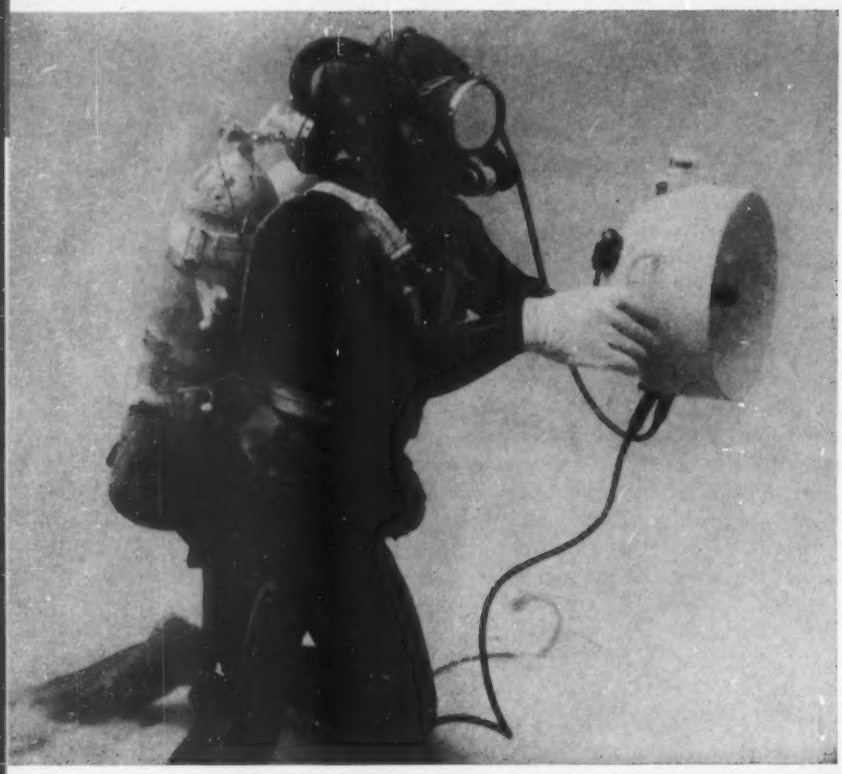
One-tenth of a pound of thrust—enough to power a rocket in the vacuum of deep space—can be supplied by an ion engine, "fueled" by 30-kw Snap-8 nuclear power sources. The ion rocket would have to be lifted out of the earth's gravitational field by a powerful booster, but low fuel consumption and high specific impulse would allow it to carry heavy payloads on long trips. Close orbits around Mars and Venus, a Jupiter satellite, and a probe to Mercury, all ion-engine missions, are possibilities to be studied by the Research Laboratories of United Aircraft Corp. for NASA. A dual-thrust propulsion system—combining ion and chemical power—will also be investigated in the $100,000 project.

who wants what, where

Future demands for new products will be indicated by data—developed from 1960 census statistics—to be made available in June. A program undertaken by S. J. Tesauro & Co., Detroit, will utilize a Remington Rand Univac to correlate population and housing-characteristics information. Results will allow a projection of the public's need for specific goods and services.

cleaner air for California

Expulsion of hydrocarbons in automobile exhaust, which will soon be a violation of the law as well as the pure air in California, is reduced 97 per cent by the Smog Burner, developed by Chromalloy Corp. It achieved this high degree of purification during downhill deceleration and idling, when pollution is normally highest; it also has reduced carbon monoxide up to 82 per cent under critical operating conditions. Chromalloy's desmogger utilizes chromallized coatings which have withstood temperatures up to 2400 F. It contains only one moving part, a valve which protects the engine from back pressure.



An audio-type "seeing" aid for frogmen working under zero-visibility conditions combines light weight with economical operation. It is a 20-lb, aluminum-housed sonar device developed by Stromberg-Carlson-San Diego and the Navy Electronics Laboratory. The fully transistorized system is powered by standard flashlight batteries.

Gas turbine powers a helicopter in a hover check flight, made to provide the first off-the-ground data on the HUL-1M plane. This is one of two Bell 47J models converted to turbine-engine power (an Allison T36). The 'copter's pylon support, tested during the flight, is said to be the softest mounting in the 47-series helicopter.

The new Mercedes-Benz 220 SE hardtop coupe is billed as having sports-car styling and performance with the comfort and safety of a touring car. It's powered by a fuel-injection, six-cylinder, overhead-cam-and-valve engine which develops 134 hp at 5000 rpm. Engine displacement is 133.9 cu in.; bore and stroke, 3.15 x 2.86 in.; compression ratio, 8.7 to 1. The 220 SE has a fully synchronized manual transmission; maximum speeds in first to fourth gears are 27.9, 47, 74, 105 mph. The car's wheelbase is 108.2 in.; overall length, 182 in. Bucket seats, standard in the front, are also available in back.

ENGINEERING NEWS

PICTURE REPORT

Subjected to the lady-driver test, an analog simulator provides data on interaction of driver and vehicle control in a human-factors research program at General Motors Research Laboratories. The trick is to keep the "car," whose front wheels are represented by two vertical bars, in its "lane," or five horizontal bars on the oscilloscope. The horizontal bars are arranged to represent a perspective view of the road ahead, and they shift horizontally to give the illusion of bends and turns. Accelerator and brake pedals determine how fast the road "picture" changes.

Not enough hot water for a good bath, but plenty for space travelers far removed from Saturday-night earth customs, is provided by a 17¼ in. high, 5½ in. diam heater for spacecraft. Three pints of 170-deg water can be drawn from it every two hours by operating a positive-displacement pressure pump. Dr. Wernher von Braun is examining the water heater; holding it is Howard Brehm, space kitchen co-ordinator for Whirlpool Corp. Whirlpool is building a space kitchen—scheduled for delivery to the Air Force in May—to store and dispense food and drink for three astronauts on a 14-day mission.

A flame representing over a million lb of thrust issues from a prototype chamber of the F-1 rocket engine in a test at Edwards Rocket Base, Edwards AFB. A single-chambered engine rated at 1.5 million lb thrust, the F-1 is being developed for NASA by Rocketdyne division of North American Aviation Inc. The thrust chamber has been fired successfully at 1,550,000 lb. Firing of a complete engine is scheduled for later this year.

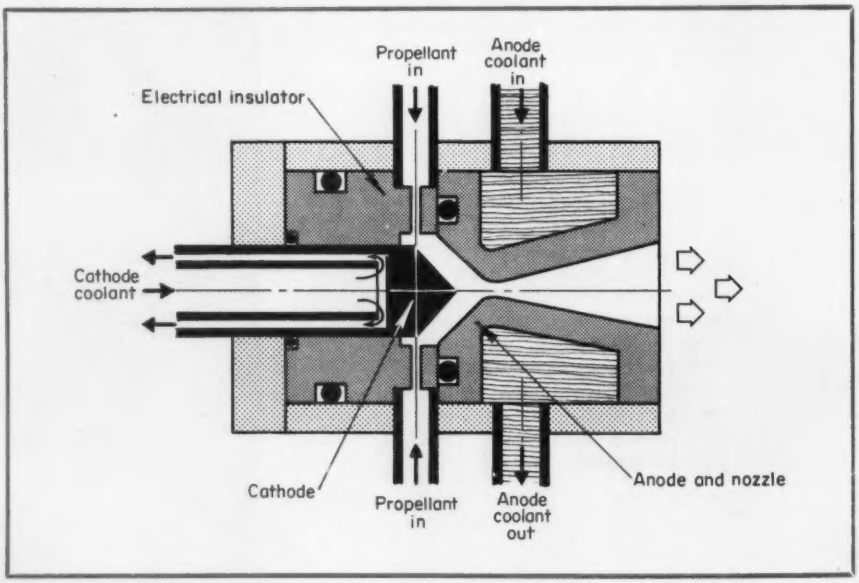
Electric Engines for Power in Deep Space

Jet velocity—the speed attained by a gas leaving a rocket nozzle—is critical in spacecraft design. As a rule of thumb, higher velocities mean smaller vehicles. Generating up to 20 times the jet velocity of chemical rockets, MHD, ion, and electrothermal engines show tremendous potential for low-thrust power outside gravity fields.

DONALD BOLDMAN
Aero. Research Scientist
Lewis Research Center, NASA
Cleveland, Ohio

GREAT advances in the field of superconductivity and the generation of fields of nearly 100,000 gauss with cryogenic magnets have led to a complete re-evaluation of the future of electrical powerplants for space applications. The door is now open for the development of high output, extremely lightweight electrical propulsion systems of very high efficiency. It is even possible that such devices may be thermonuclear in nature. This will give added impulse to the development of electrical space propulsion engines.

The need for accelerated development of electric propulsion engines becomes clear when one considers the necessity for minimizing the initial weight of a space propulsion system designed for an interplanetary mission. On the launching pad, for example, approximately 90 per cent of the weight of a conventional chemical rocket is fuel. In fact, each pound of space vehicle requires about one ton of fuel. Unfortunately, a chemical rocket is characterized by high fuel-consumption rate, or low thrust per pound of fuel consumed per second (specific impulse—having a unit of seconds). Obviously, interplanetary trips of manned vehicles with chemical propulsion will require an extremely large capital investment per trip. What is needed is a propulsion system that will produce



1. In the arc jet . . . as in other electric propulsion engines, no combustion occurs in the conventional sense. A lightweight propellant (such as hydrogen) is heated to plasma levels by a high-energy arc drawn between the electrodes. Limit on specific impulse—approximately 2000 sec—is set by temperature limits of arc-jet materials.

	Electrothermal		Ion	M.H.D.
Performance	Arc Jet	Resistance		
Specific Impulse(sec)	700 – 2000	1000	4000–10,000	10,000–25,000
Thrust (lb)	0.01–10	0.01–10	0.01–0.1	10–100
Efficiency (per cent)	80	80	90	30

considerably more thrust for each pound of fuel consumed.

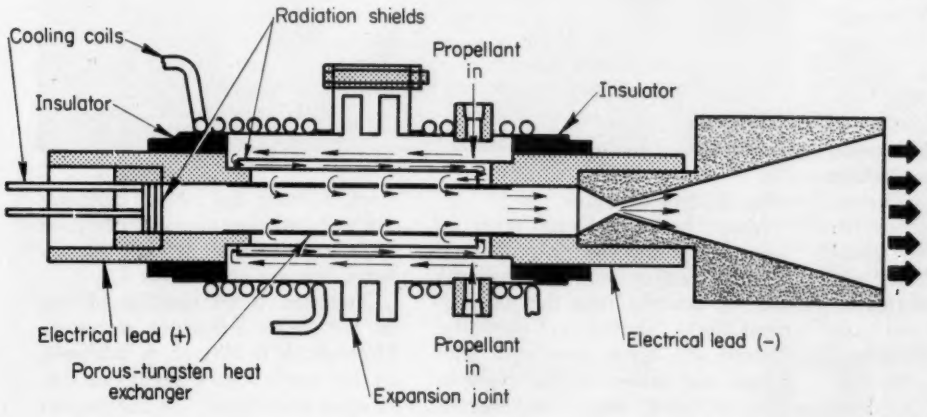
Electrical propulsion engines are capable of providing truly great increases in specific impulse. While simple chemical rockets can produce a maximum specific impulse of about 500 seconds, electric propulsion engines can achieve specific impulses ranging from about 800 to 25,000 seconds or higher.

Electric propulsion engines can be classified in three basic types:

1. Electrothermal engines
   a. Arc jet
   b. Resistance-heated engine
2. Ion engine
3. Magnetohydrodynamic (MDH) engine

The first class, electrothermal propulsion devices, produces relatively low specific impulse—2000 seconds for the arc jet; 1000 seconds for the resistance heater, using hydrogen as the propellant. Consequently, usefulness of these engines may be limited to guidance and satellite-orientation control.

The arc jet, Fig. 1, consists of two basic components—the cathode and the anode, or nozzle. An arc is drawn between the electrodes, and the propellant is heated as it passes through the arc. Efficiency of such a unit is determined by the amount of power that is consumed in heating electrodes, nozzle walls, and ballast resistors. To achieve useful efficiencies, it becomes necessary



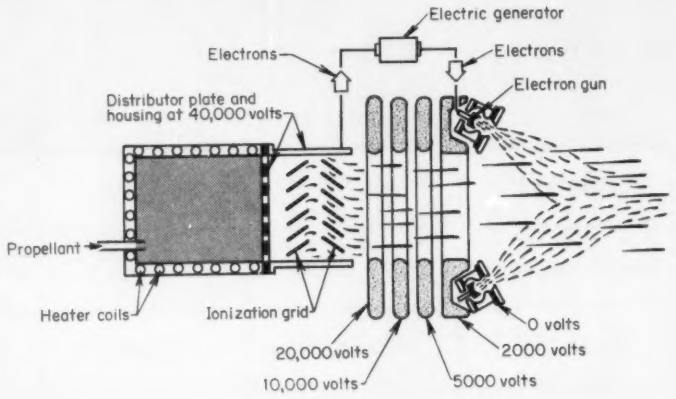
2. Resistance . . . heated engine utilizes a porous, refractory-metal resistor to heat the propellant gas. Specific impulse for hydrogen and porous tungsten propellant-resistor combination is about 1000 sec. Low-thrust electrothermal powerplants (arc-jet and resistance engines) may replace gas bottles for satellite and probe attitude control.

to regeneratively cool the components with the propellant, or to use refractory-type materials which can be operated at sufficiently high temperatures so that radiation cooling is adequate. In either case, a limit in specific impulse is reached before it becomes impossible to cool the surface. This limit is believed to be approximately 2000 seconds.

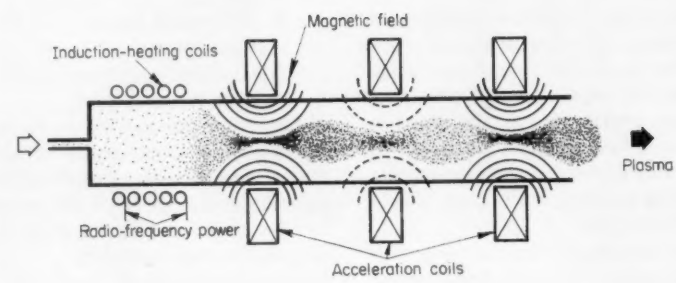
The electric resistance-heated engine, Fig. 2, utilizes a refractory metal electrical resistor to heat the propellant which flows through the porous wall. Specific impulse is limited to values attainable with the propellant heated to the maximum temperature that can be tolerated by the components of the unit. A specific impulse of approximately 1000 seconds can be achieved with a hydrogen and porous tungsten, propellant-resistor combination.

The second basic type of electric propulsion system, the ion engine, is shown in Fig. 3. The propellant is heated upon entering the unit. The very hot ionization grid strips electrons from the propellant, thus ionizing it. The grid, positively charged to 40,000 volts, repels the ions and attracts the electrons. Additional positively charged rings further accelerate the ions, and they are discharged at velocities of nearly 500,000 mph. Subsequently, the electrons are captured by the positively charged plate, flow through the outer circuit, and are discharged into space by an electron gun which is just a small version of the ion engine. Ion engines of this type are capable of achieving a specific impulse in the range from 4000 to 10,000 seconds.

The third type of electric propulsion engine, the MHD engine, is shown in Fig. 4. The MHD engine, commonly referred to as a plasma rocket or electromagnetic jet, incorporates a magnetic field rather than electrical fields to accelerate the charged partciles. In this case, the propellant is heated by radio frequency or an electric arc. The magnetic field is oriented so as to accelerate the charged particles and eject them at tremendously high velocities. The limiting speed of these particles is about 186,000 miles per second (velocity of light). Specific impulses as high as 25,000 seconds are foreseeable with this type of engine.



3. Ion engine . . .
strips electrons from an entering propellant (such as cesium) with a very hot ionization grid. Positively charged to 40,000 v, the grid repels the ions, attracts the electrons. Other positively charged rings accelerate propellant ions through the nozzle at velocities reaching 500,000 mph. Specific-impulse for the ion engine ranges from 4000 to 10,000 sec.



4. The MHD engine . . .
accelerates charged particles with a magnetic field. Propellant is heated by a radio-frequency field or an electric arc before ejection by the acceleration coils. Specific impulses as high as 25,000 sec may be possible for magnetohydrodynamic engines.

Many basic problems must be faced before the electric propulsion system (engine and powerplant) can be brought into the development phase. Problems of particular interest are those associated with design and materials. For example, How do you design an electrothermal engine to withstand a temperature of 10,000 F, retain high efficiency, and still keep the engine from burning up? New materials are required that are not only good electrical insulators at high temperatures, but are also stable.

Tungsten is an example of one of the better refractory materials. However, it is difficult to fabricate, so that much work is needed on fabrication techniques. At the present time, solutions to these problems are being sought and will no doubt be forthcoming in the near future.

TO THE CREATIVE DESIGNER...

how many hats must you wear?

All of them...if you are to execute your responsibility in equipment design *efficiently.*

Management expects equipment that can be produced profitably. *Purchasing* wants maximum value and service. *Production* expects manufacturing ease. *Sales* wants exclusive selling features. And the *customer* demands everything. No wonder designers lean heavily on suppliers who can help them satisfy all these demands.

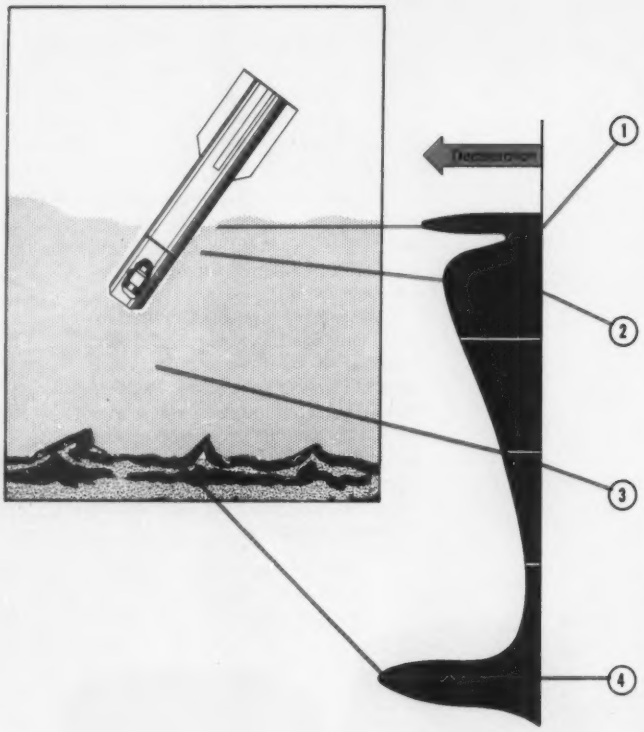
And this is exactly what CHAIN Belt delivers...help in solving problems of power drive and conveying applications. Backed by the largest, most modern test and development laboratories in the industry, we have the knowledge, the skill, the data and the products to help you design for longer life, lower costs, greater sales appeal.

Why not take advantage of the specialized service CHAIN Belt and Rex Drive and Conveyor Chains offer you! Just call your CHAIN Belt Man or write CHAIN Belt Company, 4643 W. Greenfield Ave., Milwaukee 1, Wisconsin. In Canada, write Rex Chainbelt (Canada) Ltd., Toronto and Montreal.

A CALL TO CHAIN BELT
ADDS A MAN TO YOUR STAFF
BUT NOT TO YOUR PAYROLL

REX®
CHAIN BELT COMPANY

Circle 414 on Page 19



Water-Entry Shock: Phase 2 Is Important

Idealized shock pulse for a stable, rigid missile entering water at high velocity: First phase occurs on impact when compressibility effects of water are felt. Pulse is of very large magnitude, but of such short duration that it is not damaging to most components. Precise measurement of this phase is seldom necessary; it is usually sufficient to determine whether or not the missile structure survived.

Second phase occurs as water starts flowing around the vehicle and persists until steady flow is established. Duration is approximately the time it takes for one missile length to be immersed (assuming undisturbed water). While the shock magnitude is considerably lower than that of the first phase, it is nonetheless severe.

Third phase is concerned with steady flow and is lower in magnitude, but considerably longer in duration than the second phase. Since deceleration in this phase can be computed rather simply from the relationships governing steady-state flow, its measurement is not difficult.

Bottom impact: Actual weapon would not be subjected to this force, so accelerometers in test vehicles are usually programmed to ignore it. Emphasis, then, is on instrumentation that will accurately measure the second phase.

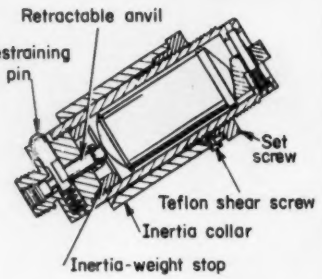
Discriminating Accelerometers Break the "Shock Barrier" in Instrumentation

DESIGN of highly sophisticated weapons systems is usually complicated by the need for test instrumentation almost as complex as the weapon itself. An unusual departure from this trend has occurred during the development of Navy's newest air-to-underwater missiles.

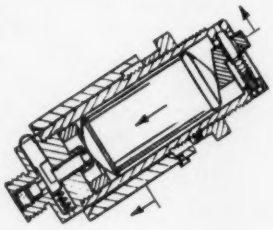
One of the critical factors in the design of these potent antisubmarine weapons is the measurement of tremendous water-entry shocks. The shocks generally consist of a high-deceleration phase (impact) lasting for a fraction of a millisecond, followed by a low-deceleration phase (drag) several orders of magnitude longer in duration than the impact. During field tests in shallow water, a third shock occurs when the vehicle hits the bottom. Test equipment must thus be capable of discriminating against one or more shocks during the same test.

Exotic continuous-recording instrumentation was ruled out because of its prohibitive cost and because impact forces were exceedingly high. Scientists at Naval Ordnance Laboratory relied, instead, on an available measurement tool—the familiar copper-ball accelerometer. They redesigned it and came up with a straightforward mechanical device that has proved highly useful in measuring forces imposed on a missile as it enters the water.

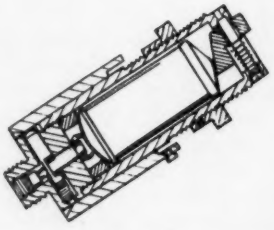
The conventional copper-ball accelerometer



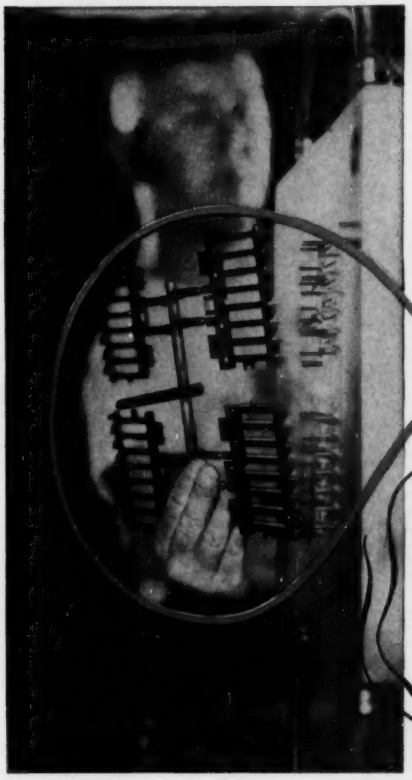
"Armed" prior to surface impact, this accelerometer is designed to discriminate against all forces except the peak impact force (1, above). Inertia weight, resting on the copper ball, deforms the ball at impact. Simultaneously . . .



. . . **initial shock** also actuates the inertia collar, which shears the Teflon screw. Several milliseconds later, depending on the position of the set screw and the intensity of the shock, the collar engages the restraining pin, driving it inward and causing it to release the anvil . . .

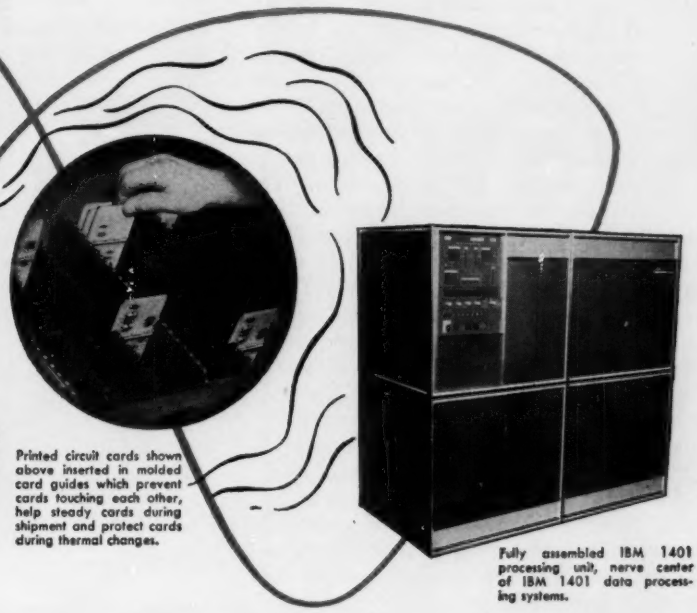


. . . **the ball drops** clear of the inertia weight, and recording is interrupted. Recording period can be varied by adjusting the set screw.



Thermoplastic card guides for IBM 1401 processing unit, ejecting from precision molding dies at Quinn-Berry Corporation, Erie, Pa.

NERVE CENTER OF "Electronic Mathematician" protected by . . . PRECISION CARD GUIDES



Printed circuit cards shown above inserted in molded card guides which prevent cards touching each other, help steady cards during shipment and protect cards during thermal changes.

Fully assembled IBM 1401 processing unit, nerve center of IBM 1401 data processing systems.

Molded of LEXAN® Thermoplastic by Quinn Berry

CHELSEA 50, Mass.
Joseph Leader
68 Marlborough Street
Tumer 4-3484

DETROIT 35, Mich.
W. J. Montgomery Co.
16577 Meyers Road
Diamond 1-3454

EAST ROCHESTER, N. Y.
Dynatherm, Inc.
707 West Commercial Street
Phone: Ludlow 600-80

KNOXVILLE, Tennessee
Melloy Sales Inc.
P.O. Box 3207—Zone 17
2643 Kingston Park S.W.
IBM Bldg.
Phone Knoxville 522-5911

MILWAUKEE 13, Wis.
John Weiland, Jr.
7105 Grand Parkway
Greenfield 6-7161

ARDMORE, Pa.
Austin L. Wright Co.
P. O. Box 561
1 W. Lancaster Ave.
Midway 2-5113

In the IBM 1401 processing unit, nerve center of IBM 1401 data processing systems, it is of paramount importance that Card Guides help maintain card position during movement and thermal changes.

Quinn-Berry's skilled precision mold design and engineering teams up with experienced press room operation to meet IBM close tolerance specifications. Skilled craftsmen mold IBM Card Guides of Lexan® polycarbonate resin, a product of General Electric Plastics Division, to meet the most rigorous requirements. The result—parts which have excellent dimensional stability, extreme resistance to impact and which are self extinguishing.

Your requirements for precision molded thermoplastic parts can be fully satisfied at Quinn-Berry—place them with us in full confidence. Here, the Unusual is Routine.

WE FLY TO SERVE YOU FASTER!

QUINN-BERRY CORP.
2609 WEST 12TH STREET, ERIE, PA.
CUSTOM MOLDERS OF ALL TYPES OF THERMOPLASTICS

Circle 415 on Page 19

consists essentially of a weight, copper ball, anvil, and housing. During a shock, the weight is forced against the ball, deforming it. Measuring the amount of deformation and comparing it with deformations obtained under static test reveals the magnitude of the shock.

Conventional copper-ball accelerometers used at NOL cover a shock range from 30 to 20,000 g; natural frequencies run from 228 cps in the low-g region to 1760 in the high-g region. Accuracy is better than 80 per cent for simple shock pulses having build-up times at least five times the natural period of the accelerometer. For shock pulses having shorter buildup times, the accelerometer will tend to overshoot. To accurately interpret the peak shock in this region, dynamic-load factors must be considered —factors which can be as high as 1.8 for half-sine pulses or 1.5 for triangular pulses. If an accelerometer is selected with a natural period approximately twice that of the shock pulse, the accelerometer functions as a velocity meter or as a seismic device—deformation of the copper ball is directly proportional to the velocity change.

Discriminator mechanisms developed at NOL for the copper-ball accelerometer permit a particular shock to be measured by inertially delaying or interrupting the action of the instrument. Depending on the design of the discriminator mechanism, either the initial or the final shock can be recorded.

Not Quite Ideal

Although discriminators have greatly increased the usefulness of copper-ball accelerometers, they by no means solve all the problems of shock recording, according to NOL scientists. At best, these devices still indicate only peak acceleration or velocity change at one or two points in a particular shock pulse. Some knowledge of the characteristics of the shock under study is required in order to interpret measurements with acceptable accuracy.

NOL Scientists would like to obtain rugged, reliable instrumentation with the following characteristics:

Sensitivity (accelerometer): 50 mv at maximum g value.

Range (accelerometer): 100 to 20,000 g.

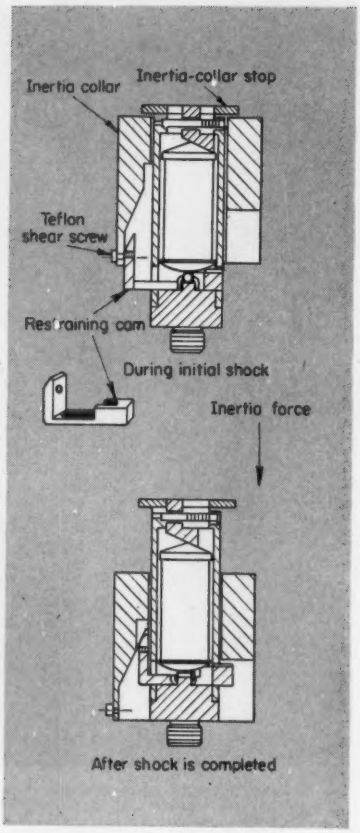
Frequency response (system): Essentially flat from dc to 10,000 cps

Damping (accelerometer): 0.3 of critical.

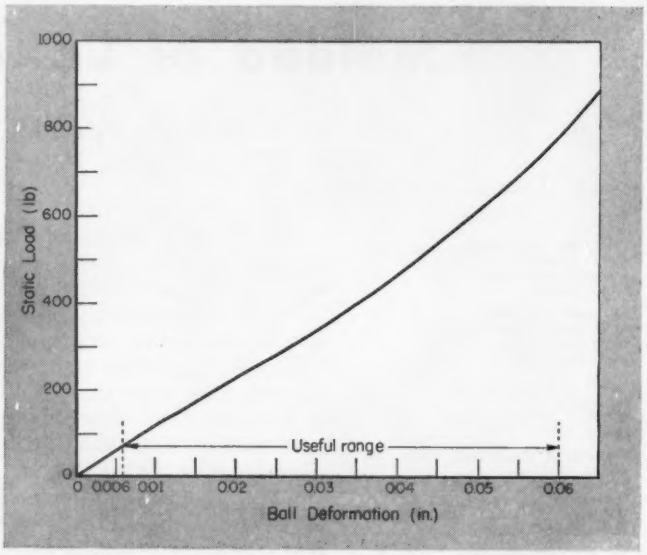
Accuracy (system): 5 per cent.

Shock integrity (system): Continuous recording during shock, capable of withstanding up to 10,000 g for 500 microseconds, followed by a minimum of 1000 g for 100 milliseconds

Configuration (system): Except for accelerometers, the system should consist of a single cylindrical package. Envelope size should be adaptable to various missile sizes.



Impact shock is ignored by this accelerometer—recording is delayed several milliseconds until the restraining cam releases the inertia weight to operate on the ball. The discriminating mechanism thus permits recording of the peak water-entry drag or the bottom impact.



All accelerometers used by Naval Ordnance Laboratory contain 5/32 in. copper balls . . . they exhibit acceptable linear load-deformation characteristics over a wide range, thus simplifying analysis of readings. Permanent deformation of the balls is measured with micrometers, and the corresponding load is determined from the static-calibration curve, above. Acceleration, g, is equal to the static load divided by the value, lb, of the inertia weight. Response of the accelerometer has a linear dependence with temperature, the deformation at −65 F being approximately 15 per cent less than that at 160 F for equivalent loads. Under nonaxial loads up to 60-degree obliquity, the accelerometer responds to the peak axial component within ±10 per cent.

Only from OHMITE

MIL-R-19365C Across the Board!

OHMITE "Dividohm®" Adjustable Resistors

HIGHLIGHTS OF MIL-R-19365C.—This revised specification covers power-type, wire-wound, adjustable resistors from 1 to 15,000 ohms inclusive. Resistance tolerance is specified as ± 5% for all eight power ratings which are listed at right. The maximum continuous operating temperature is 350°C (Char. V).

MIL-R-19365C resistors are the tubular type with single-layer windings and lug-type terminals—two fixed and one adjustable.

Ohmite can supply all eight adjustable resistors to meet *every* requirement of MIL-R-19365C. Higher resistances using smaller wire sizes are available, also, to meet the performance requirements of this new MIL specification.

Write for Military Catalog 50B—the "Easy Way" to Order MIL Resistors.

STANDARD MIL-R-19365C ADJUSTABLE RESISTORS

STYLE	WATTS	DIMENSIONS		OHMS	
		LENGTH	DIA.	MIN.	MAX.*
RX29	11	1¾"	7/16"	1	470
RX32	17	2"	9/16"	1	910
RX33	26	3"	9/16"	1	1,500
RX35	55	4"	29/32"	1	3,600
RX36	78	4"	1 5/16"	1	5,100
RX37	113	6"	1 5/16"	1	8,200
RX38	159	8"	1 5/16"	1	11,000
RX47	210	10½"	1 5/16"	1	15,000

*0.004" Diameter wire.

Offering you complete availability of these MIL resistors so quickly is another indication of Ohmite's ability and desire to give industry the finest, most advanced resistance products with the best of service.

OHMITE MANUFACTURING COMPANY
3618 Howard Street, Skokie, Illinois

Rheostats Power Resistors Precision Resistors
Variable Transformers Tantalum Capacitors
Tap Switches Relays R.F. Chokes
Germanium Diodes Micromodules

OHMITE

BuShips Backs Research On Sodium Fuel Cell

Prototype Doubles H_2-O_2 Cell Output

NEW YORK—A new type fuel cell, now in the prototype-construction stage, may supplant storage batteries on warships. Designed to deliver 75 kw, the prototype powerplant will be 15 times lighter than batteries of the same capacity, will weigh less than 3 lb per kw-hr.

Being developed for the Navy by M. W. Kellogg Co. (subsidiary of Pullman Inc.), the fuel-cell system will operate on oxygen and an amalgam of sodium in mercury. This relatively unfamiliar type of cell has several advantages over hydrogen-oxygen systems:

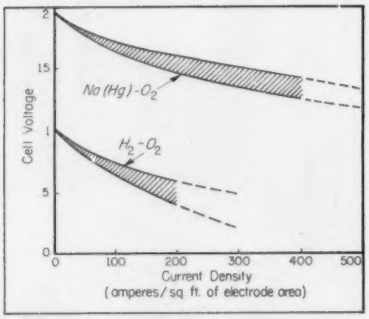
- It develops twice the voltage, needs fewer cells for the same size powerplant.
- It requires less space for fuel storage.
- Sodium fuel can be more safely handled than hydrogen.

"Three separate technological areas are involved in designing and building an engine of this sort," says Dr. Alex G. Oblad, Kellogg's vice president of research and development. "First is the fuel cell itself, but this area now presents few problems. An earlier research program proved its feasibility for Naval applications, although bringing to light many engineering problems that would have to be solved."

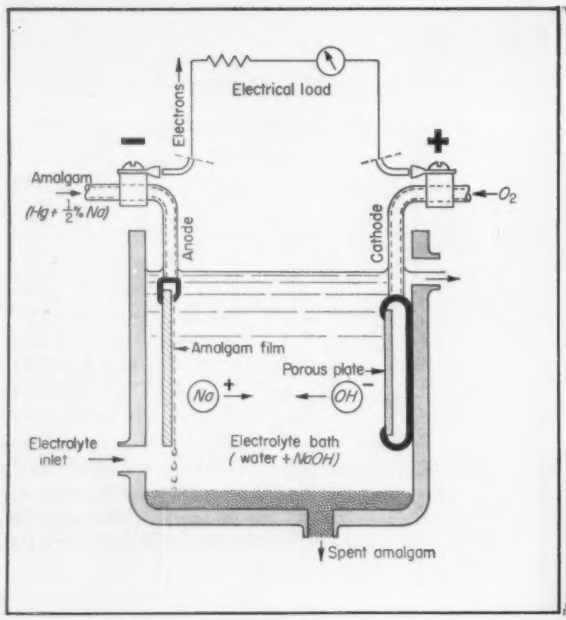
The second area—that of resolving engineering problems—has also been completed; cells have been constructed and auxiliary hardware designed. The Navy has been convinced that a fuel-cell system can be developed to the specific requirements dictated by warship applications.

The job remaining is to convert the laboratory model into a practical powerplant. A realistic duplication of actual operating conditions will be required. For example, using a simulator, designers will put the prototype through pitch, roll, and yaw tests.

The contract, with the Bureau of Ships, calls for the company to design and test a complete Naval powerplant. According to Warren L. Smith, president of Kellogg, this decision represents "one of the first large applications of the fuel-cell principle to specific power and service requirements."



Open-circuit voltage of the sodium cell nearly doubles that of hydrogen-oxygen units. Voltage falls off as current picks up, but ohmic and electrode losses can be made quite small, and large currents can be drawn from single cells. The 2-volt output, a major advantage of the device, is due to the high position of sodium in the electromotive series.



How It Works:

An explosion would occur if a pure-sodium electrode were immersed in aqueous electrolyte, so a dilute solution (amalgam) of sodium in mercury is used. The amalgam flows down a steel plate, forming a thin film on the surface. The film, acting as the anode, gives up electrons to the electrical circuit and sodium ions to the electrolyte. Depleted amalgam falls to the bottom of the cells and is removed. Oxygen gas is supplied to a hollow cathode that has a porous sintered-metal plate as one surface. At the cathode, electrons from the anode react with the oxygen and water from the electrolyte, forming hydroxyl ions. In the electrolyte, sodium and hydroxyl ions combine to generate caustic soda (NaOH). The cell operates at atmospheric pressure and at a 140-F temperature.

Gates advanced design drive **SAVES** money, space, weight

on every machine you make

The machines you design can be more compact, lighter weight and lower cost by using Gates Super HC High Capacity V-Belt Drives. Because of exclusive construction features, this high capacity drive — industry's first — can often cut in half the space formerly required for a V-belt drive. Gates Super HC Drive is your best assurance that your power transmission unit will not soon become obsolete.

The Gates Field Engineer near you is an experienced, fully-qualified drive design expert. Contact him for drive design help.

The Gates Rubber Company, Denver 17, Colorado

Gates

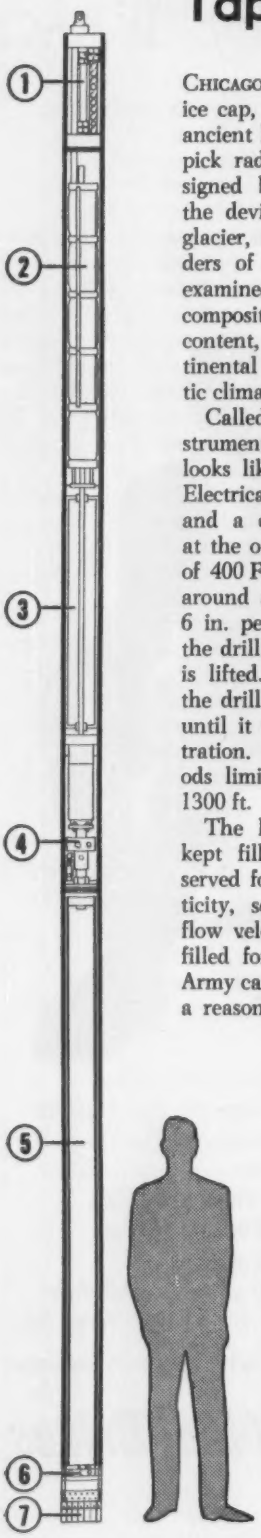
Building the future on 50 years of progress

Gates Super HC V-Belt Drives

BP-9

Circle 417 on Page 19

Thermal Drill Taps the Poles

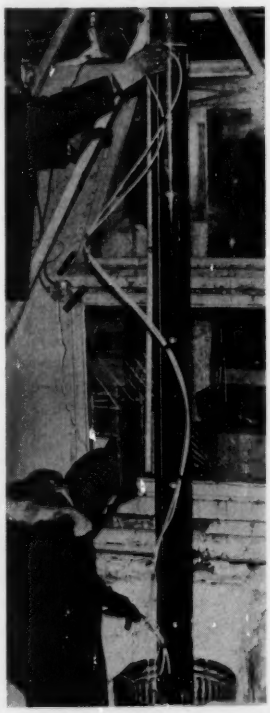


CHICAGO—Probing 12,000 ft into an ice cap, a new heating tool digs up ancient history as it helps the Army pick radar sites in the Arctic. Designed by Pollack and Skan Inc., the device sinks a 6-in. hole in a glacier, capturing 10-ft long cylinders of ice as it goes. The cores, examined for structure, chemical composition, and insoluble-particle content, provide data on the continental ice sheets and former Arctic climates.

Called a thermal drill, the instrument measures about 23 ft long, looks like a hollow telephone pole. Electrical equipment is at one end and a circular heating element is at the other. Heated to a maximum of 400 F, the element melts its way around a core of ice at the rate of 6 in. per min. The core is held in the drill and removed after the drill is lifted. Once a core is unloaded, the drill can be sunk another 10 ft, until it reaches its maximum penetration. Mechanical drilling methods limit ice coring to a depth of 1300 ft.

The hole made by the drill is kept filled with oil which is observed for temperature profile, plasticity, seismic-wave velocities, and flow velocity. The holes will be oil filled for several years so that the Army can measure data changes over a reasonable time interval.

Each time an ice core fills the storage chamber, the drill is brought back to the surface and the ice removed (above). Melt water, pumped into a tank when the drill is cutting, is drained out once the ice chamber is empty (right).



Built in sections, the 800-lb drill forms a straight, rigid structure that will not bind in ice. Power cable (2300 v) attaches to an oil-filled terminal chamber (1); power is stepped down to 230 v in the transformer chamber (2). As the drill melts through the ice, water formed is pumped into a storage tank (3) by a submersible pump and motor (4). The ice core is held in a core barrel (5) that signals the crew when it is full (via a limit switch). At this time, the core cutter (6) separates the core from the ice, holding it in place while the drill is raised. The drill head (7) consists of 20-cartridge-type heating elements arranged in a circle.

Circle 418 on Page 19→

do you need a higher efficiency small blower wheel?

LAU®

FIRST CLASS
PERMIT NO. 182
DAYTON, OHIO

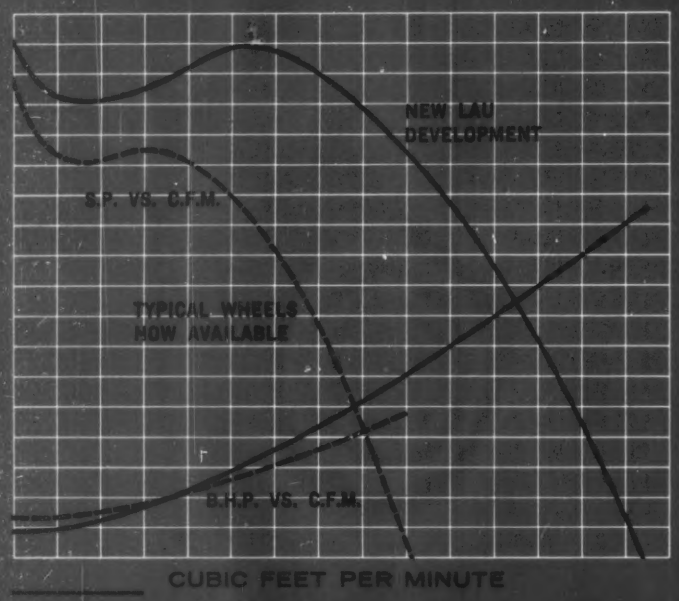
BUSINESS REPLY MAIL
No Postage Stamp Necessary if Mailed in the United States

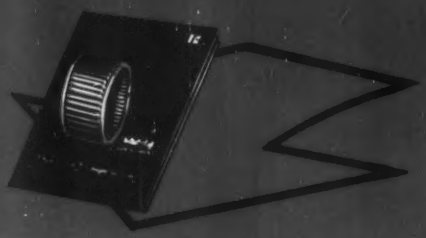
POSTAGE WILL BE PAID BY

Mr. William H. Wentling, Director of Engineering
THE LAU BLOWER COMPANY
2027 Home Avenue
Dayton 7, Ohio

INTRODUCING A NEW LAU ENGINEERED BLOWER WHEEL... 4 3/4" TO 8 1/2"

BLOWER PERFORMANCE





Lau Engineering has successfully developed a blower wheel that outperforms any wheel of comparable size tested. This powerful, compact unit is specifically designed for installation in room air conditioners but can be used effectively in most appliance applications. Lau "spun" construction contributes greatly to the wheel's structural rigidity and to a very high CFM to WATT ratio.

This new Lau wheel is offered in a customer's choice of aluminum, cold rolled steel or zinc grip and in a range of diameters, blade lengths, bore sizes and back plate designs.

For a complete engineering data file on this new Lau high performance wheel send the attached, postage paid card to Wm. H. Wentling, Director of Engineering, The Lau Blower Company, 2027 Home Ave., Dayton 7, Ohio.

Mr. William H. Wentling, Director of Engineering
THE LAU BLOWER COMPANY
2027 Home Avenue
Dayton 7, Ohio

Please check

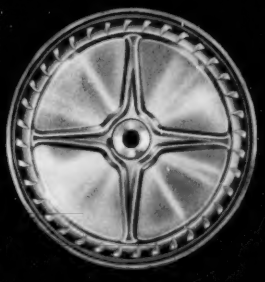
☐ send complete engineering file ☐ we would like to see sample wheel

Name_____

Position_____

Company Name_____

Address_____



Single inlet wheel is standard. Double inlet (wheels back to back) is available. Choice of solid, pied-out or coned back plate.

Metals Matters

Painted aluminum . . .
that retains its reflective luster has been developed by Reynolds Metals Co., Richmond, Va. On bright sheet, Reflective Colorweld has a mirror-like quality superior to color anodizing, according to Reynolds, and on all other surfaces, it is as bright as color anodizing. Also, aluminum with the new finish can be formed with less likelihood of damage than anodized aluminum. Suitable for appliance and automotive trim, Reflective Colorweld is made in ten colors with either bright, embossed, or brushed finish.

Spherical powders . . .
offer improved quality of sintered parts and better flowability, according to Thermal Dynamics Corp., Lebanon, N. H., which is now producing metals, ceramics, refractory metals, oxides, carbides, and other materials in this form. Spheroidization of particles permits high-density vibration packing or produces controlled-porosity bodies through pressing and sintering. Spherical powders of zirconia, alumina, mullite, tungsten, stainless, copper, aluminum, etc., can be furnished in standard ASTM sieve sizes from 100 through 325.

Jet-black dyeing . . .
of anodized aluminum can be done in 15 minutes, at 12 amp per sq ft of surface area, with a process developed by Colonial Alloys Co., Philadelphia. Result is a deep, hard, clean surface. Conventional methods take 45 to 60 minutes of anodizing and often result in dull, relatively soft, and smutted surfaces.

Corrosion resistance . . .
has been increased in type 433 stainless steel, developed by Allegheny Ludlum Steel Corp., Pittsburgh, for automotive use. The new alloy is similar to type 430, with molybdenum and copper added. It has stood up well against corrosion in laboratory tests, and hub caps and moldings are now being service-tested.

A piece of platinum . . .
attached to a tantalum part prevents hydrogen embrittlement, according to Union Carbide Metals Co., division of Union Carbide Corp., New York. In some cases, corrosion rate of the tantalum actually decreases.

Permanent self-lubrication . . .
is built into Deva metal, a homogeneous and nonporous solid manufactured by Universal Metallic Packing Co. Ltd., England. The material is made by compacting natural or colloidal graphite powder with primary or alloyed metal powders. Friction causes formation of a graphite film on the contacting metal surface. Various grades of bronze, brass, and iron are used as the metallic constituent of Deva metal, covering the operating temperature range of −330 to 1100 F. The material is easy to machine, has Brinell hardnesses between 50 and 82, compression strengths from 12 to 18 tons per sq in. Coefficients of friction vary from 0.05 under favorable conditions to 0.3 under very unfavorable conditions.

Nuclear certification . . .
for its aluminum welding and brazing alloys 718, 1100, and 4043 is announced by All-State Welding Alloys Co. Inc., White Plains, N. Y. Nuclear-grade alloys are certified to contain less than a specified amount of lithium, cadmium, boron, and cobalt.

Precision cold extrusion . . .
was used to produce titanium fittings by Battelle Memorial Institute for the Manufacturing and Materials Technology Div., Air Materiel Command Aeronautical Systems Center, U. S. Air Force. In a pilot run, No. 10 size hexagonal nuts for MS-type aircraft quality flareless tube fittings were extruded, finish machined, and threaded at a little more than half the cost of conventional steel or aluminum nuts produced entirely on automatic screw machines. Part of the savings is in stock: The starting billet used in cold extrusion weighs only half as much as one required for screw machining, and it can be cut from round, instead of hexagonal, bar stock.

Meetings and Shows

April 4-6—
National Microfilm Association. Tenth Annual Meeting and Convention to be held at the Sherman Hotel, Chicago. Additional information can be obtained from the association's executive secretary, Vernon D. Tate, P. O. Box 386, Annapolis, Md.

April 4-7—
Society of Automotive Engineers Inc. National Aeronautic Meeting, including production forum and display, to be held at the Hotel Commodore, New York. Further information is available from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

April 5-7—
Institute of Environmental Sciences. Annual Technical Meeting and Equipment Exposition to be held at the Park Sheraton Hotel, Washington, D. C. Further information can be obtained from Henry F. Sander, executive secretary of IES, P. O. Box 191, Mt. Prospect, Ill.

April 6-7—
American Society of Mechanical Engineers-Society for the Advancement of Management. Management Engineering Conference to be held at the Statler Hilton Hotel, New York. Further information can be obtained from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

April 9-13—
American Society of Mechanical Engineers. Oil and Gas Power Conference and Exhibit to be held at the Jung Hotel, New Orleans. Additional information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

(Please turn to Page 42)

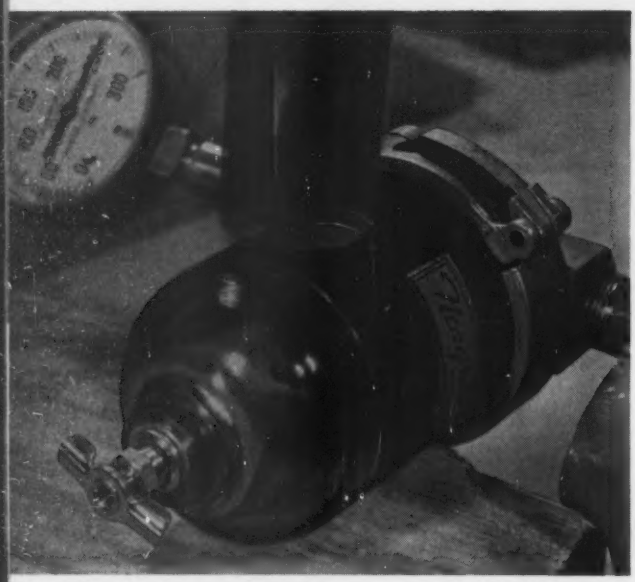
"How are things otherwise?"

←Circle 418 on Page 19

NEW NORGREN SAFETY GREEN* TRANSPARENT BOWL WITHSTANDS RIPPING IMPACT OF BULLETS

*TRADEMARK

Norgren SAFETY GREEN* bowl doesn't shatter... yet is fully transparent



Heavy steel bar dropped endwise from 12 ft. height merely scuffed surface of bowl carrying over 200 psi internal pressure.

Bowls for compressed-air-line filters and lubricators should be transparent to permit quick visual inspection. However, in the past, unusual or special applications often required the use of bowl guards or wire reinforcements . . . sacrificing the advantage of transparency.

Now . . . from Norgren . . . you get a fully transparent, yet super-tough, impact-resistant bowl designed for even the most severe service. As these photos dramatically portray, the new Norgren bowls are transparent and are able to withstand conditions far more exacting than ever encountered in ordinary use. Non-shattering bowls mean reduced replacement cost, less air-tool and equipment down-time, savings in maintenance and operating costs, greater employee safety.

These new SAFETY GREEN* bowls are now available for most Norgren air-line filters and lubricators—or may be obtained separately for replacement purposes from your local Norgren representative or distributor. Or, write for full information.

As a further test of toughness, the new Norgren bowl was placed in a heavy machine shop vise . . .

then compressed almost flat. Even in this extreme position, the bowl did not break or even crack.

Turned and squeezed again back to its original shape, the bowl still showed no cracking. Except for vise marks almost good as new!

...WITH NO SHATTERING!

Unretouched high-speed photo by University of Denver Research Dept. shows new Norgren SAFETY GREEN Bowl a split second after penetration by bullet. Initial pressure of 285 psi is being relieved through bullet hole.

Specify Norgren SAFETY GREEN Bowls

Large photo shows bowl after test. Only damage to bowl is clean bullet hole with no cracking, crazing or shattering. Impact has broken gauge. This test clearly demonstrates extreme toughness of Norgren SAFETY GREEN bowls.

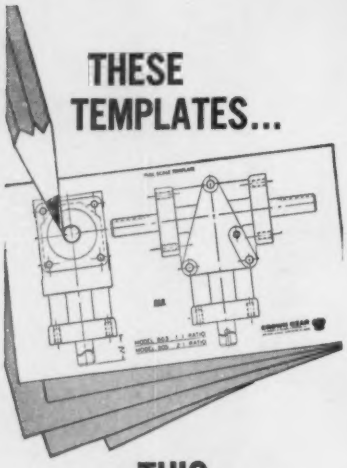
FOUNDED IN 1926

. . . for complete information, write

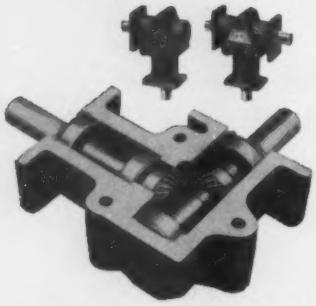
C. A. NORGREN CO.

3442 SOUTH ELATI STREET ENGLEWOOD, COLORADO

Circle 419 on Page 19



THIS
CROWN
"PACKAGE"



wrap up
your right-angle
design problem!

. . . And the transition to the "Package" concept of right-angle power transfer is that simple with this easy-reference template kit. 18 basic Crown right-angle units are shown on six template sheets, each full scale.

WHY spend countless hours on research and drawings? WHY purchase expensive patterns, core boxes, castings, steel and other materials? WHY manufacture fixtures and gages? WHY machine, inspect, assemble and test components?

WHY NOT OBTAIN THE IDEAL SOLUTION TO YOUR RIGHT-ANGLE PROBLEM . . . IMMEDIATELY, AND AT TREMENDOUS SAVINGS?

Your local Crown Gear Distributor (Listed in Power Transmission Design Directory) has the answers . . . and your Template Kit. Call him or consult factory.

CROWN GEAR

320 PARK AVE., WORCESTER 10, MASS.
A Division of Harrington & Richardson, Inc.

Circle 420 on Page 19

(Continued from Page 39)

April 10-11—

Society of Naval Architects and Marine Engineers. Annual Spring Meeting to be held at the Hotel Mark Hopkins, San Francisco. Further information can be obtained from society headquarters, 74 Trinity Place, New York 6, N. Y.

April 10-14—

International Institute of Welding. Annual Assembly, to be held at the Sheraton-Atlantic Hotel, New York, will join the American Welding Society meeting the following week. Additional information is available from AWS headquarters, 33 W. 39th St., New York 18, N. Y.

April 11-13—

American Society of Lubrication Engineers. Annual Meeting to be held at the Bellevue-Stratford Hotel, Philadelphia. Further information can be obtained from ASLE headquarters, 5 N. Wabash Ave., Chicago 2, Ill.

April 17-19—

Fifth Conference on Manufacturing Automation, cosponsored by Purdue University and Manufacturing Engineering Council and *Automation* magazine, to be held at Purdue University, Lafayette, Ind. Further information is available from K. E. Glancy, Div. of Adult Education, Purdue University, or *Automation*, Penton Bldg., Cleveland 13, Ohio.

April 17-21—

American Welding Society. 42nd Annual Convention and Welding Exposition to be held at the Coliseum, New York. Technical meetings will be held at the Commodore Hotel. Additional information is available from society headquarters, 33 W. 39th St., New York 18, N. Y.

April 17-21—

Business Equipment Exposition to be held in the Coliseum, New York. Sponsor is the Office Equipment Manufacturers Institute. Further information is available from OEMI, 777 14th St. N.W., Washington 5, D. C.

April 18-20—

New England Electrical Trade Show to be held in the Commonwealth Armory, Boston. Sponsor is the Electrical Manufacturers Representatives Club of New England. Additional information can be obtained from Charles A. Stone, 45 Morrissey Blvd., Boston 25, Mass.

April 20-21—

Society of the Plastics Industry Inc. Annual Western Section Conference to be held at the Hotel del Coronado, Coronado, Calif. Further information can be obtained from SPI headquarters, 250 Park Ave., New York 17, N. Y.

April 23-26—

American Society of Mechanical Engineers. Metals Engineering Conference to be held at the Penn Sheraton Hotel, Pittsburgh. Further information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

April 24-26—

American Society of Mechanical Engineers. Annual Conference of the Metals Engineering Div. to be held at the Penn-Sheraton Hotel, Pittsburgh. Further information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

April 26-27—

High-Temperature Materials Conference to be held at the Pick-Carter Hotel, Cleveland. Sponsor is the Cleveland section of the American Institute of Mining, Metallurgical, and Petroleum Engineers, in co-operation with the High Temperature Alloys Committee and the Refractory Metals Committee of the Institute of Metals Div. of the Metallurgical Society. Further information is available from the Metallurgical Society of AIME, 29 West 39th St., New York 18, N. Y.

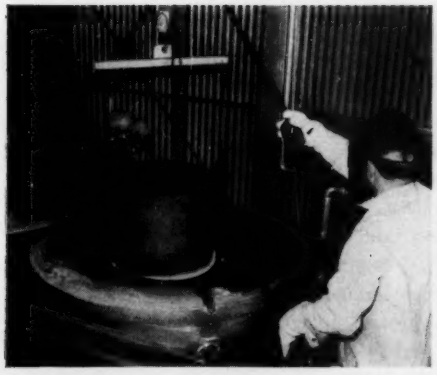
April 26-28—

Institute of Radio Engineers. 1961 Conference of the Seventh Region to be held at the Hotel Westward Ho, Phoenix, Ariz. Further information can be obtained from Everett Eberhard, Motorola Military Electronics Div., 8201 E. McDowell Rd., Scottsdale, Ariz.

May 2-3—

Lead Industries Association. Annual Meeting to be held at the

2300° HOT . . . *but not bothered!*



Retort made of HASTELLOY alloy X is removed from furnace after brazing cycle at 2300 deg. F.

RETORTS made of HASTELLOY alloy X and used for controlled-atmosphere brazing of rocket and missile parts at 2300 deg. F—last up to twice as long as retorts previously used. The alloy's high strength and resistance to oxidation and thermal shock make thinner walls possible. This in turn shortens heating cycles by 25 per cent . . . and cuts fuel costs by as much as 40 per cent.

Total savings during the 100-day lifetime of the retorts is about $1000—resulting from lower first cost, shorter heating cycles, 150 additional cycles per retort, and reduced costs for fuel and welding maintenance.

Resistance to stress, to thermal shock, to erosion, corrosion, and fatigue, are typical properties that make HAYNES alloys so extremely useful in jet engine turbine wheels, in ramjets, missiles, rockets, as well as industrial heat-treating applications.

Whether investment- or sand-cast, rolled, wrought, vacuum melted, or air melted, there's a HAYNES high-temperature alloy to meet your needs.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of Union Carbide Corporation

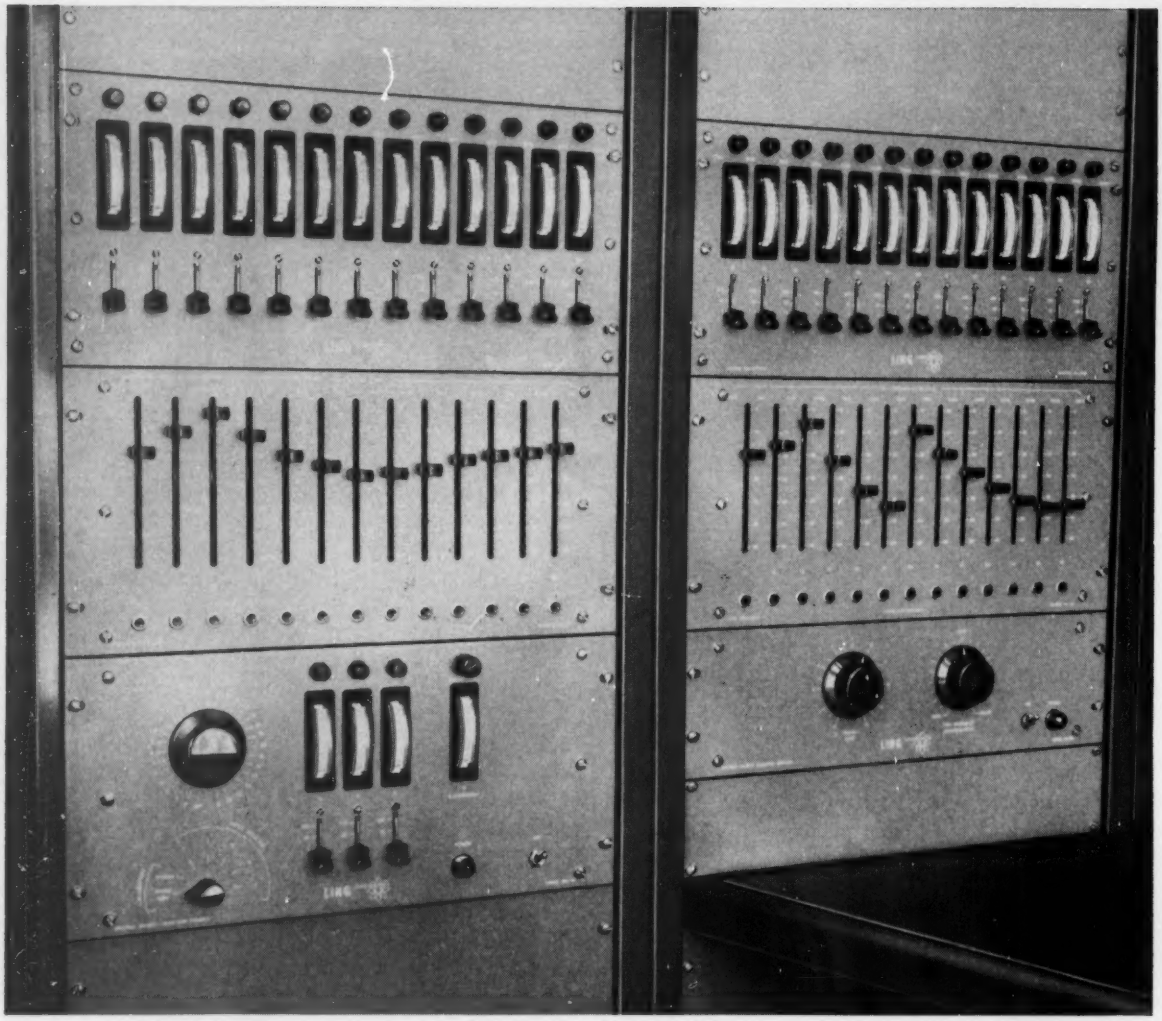
Kokomo, Indiana

Address inquiries to Haynes Stellite Company, 270 Park Avenue, New York 17, New York.

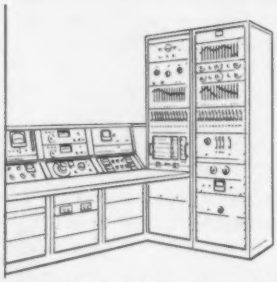
UNION CARBIDE

"Haynes," "Hastelloy," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Circle 421 on Page 19



MILLIONS SAVED IN TEST SET-UP TIME with Ling's Dynamic Equalizer/Analyzer...the Industry Standard



More than 40 of these popular-priced equalizing systems are now in continuous service on all major missile projects and in private testing laboratories. Here's why. Only Ling's new Dynamic Equalizer/Analyzer System permits you to set up a shaped input faster, analyze unknown spectral density at a glance, and equalize spectrum variations rapidly even while the test is in progress. Actual field experience shows a ten to one savings in test time over conventional methods. Ling engineering makes the difference! This remarkable system features simplified controls. A series of separate filters split the entire bandwidth of 10 to 2000 cps into segments of 100 cps or less, providing the operator independent control over each segment with separate adjustable attenuators. Band pass characteristics of the analyzer filters are matched to those of the equalizer giving the operator a continuous picture of the shaker acceleration output. The analyzer continuously and simultaneously reads out each channel in g^2/cps. Corrections in energy distributions can be made immediately by simply adjusting the filter attenuators. Ling provides fast set up, sure control, and continuous readout directly calibrated in g^2/cps on individual meters. For details of the ESD/ASD-20, write Dept. MD-361 at our Anaheim address.

LING-TEMCO ELECTRONICS, INC.

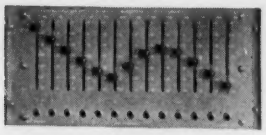
LING ELECTRONICS DIVISION

1515 SOUTH MANCHESTER, ANAHEIM, CALIFORNIA • PRospect 4-2900

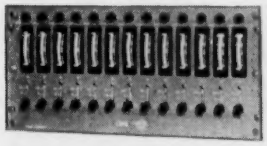
Circle 422 on Page 19

LING ELECTRONICS

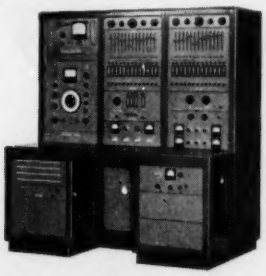
The dynamic Equalizer/Analyzer System shown at the left is just one of the numerous improvements to grow out of Ling's research and development program.



The LING SPECTRAL DENSITY EQUALIZER consists essentially of 26 sharp cutoff band pass filters and a low frequency compensating control that are driven from a common source. The filters cover the 10-2000 cps frequency range and separate the input test signal into 26 narrow frequency bands. By individually adjusting the filter outputs, the spectrum of the input signal can be shaped to compensate for any undesirable transfer characteristics in the shaker, fixture, or the specimen being tested.



The LING SPECTRAL DENSITY ANALYZER includes 30 sharp cutoff band pass filters all driven from a common source. Twenty-six of the filters duplicate the frequency bands of the ESD-20 Equalizer. Each filter output signal may then be read directly calibrated to g^2/cps on the analyzer meters. Three of the other four filters serve as indicators for the spectrum from 10 to 70 cps and one reads total rms g above 2000 cps. No time consuming conversion is necessary.



A typical Ling sine and minimum random console available in multiple cabinet configurations.

LING-TEMCO ELECTRONICS, INC.
LING ELECTRONICS DIVISION

HIGH POWER ELECTRONICS FOR
VIBRATION TESTING • ACOUSTICS • SONAR

Drake Hotel, Chicago. Additional information can be obtained from association headquarters, 292 Madison Ave., New York 17, N. Y.

May 8-12—

American Foundrymen's Society. Castings Congress and Exposition to be held at Brooks Hall and the Civic Auditorium, San Francisco. Further information can be obtained from AFS headquarters, Golf and Wolf Roads, Des Plaines, Ill.

May 8-12—

National Industrial Production Show of Canada to be held at the Industry and Coliseum buildings, Canadian National Exhibition Park, Toronto. The Canadian section of the American Society of Mechanical Engineers is among the sponsors. Additional information on the show is available from E. M. Wilcox Ltd., 19 Melinda St., Toronto, Canada.

May 9-11—

Western Joint Computer Conference to be held at the Ambassador Hotel, Los Angeles. Further information can be obtained from conference headquarters, 721 N. La Brea Ave., Los Angeles 38, Calif.

Short Courses and Symposia

March 28—

17th Annual Quality Control Clinic to be held at the University of Rochester, Rochester, N. Y. Sponsor is the Rochester Society for Quality Control. Further information can be obtained from Albert D. Rickmers, Associate Professor, College of Graphic Arts and Photography, School of Photography, Rochester Institute of Technology, 65 Plymouth Ave. South, Rochester 8, N. Y.

March 28-29—

Symposium on Nucleonics in Flight to be held at the Statler-Hilton Hotel, Dallas, Texas. Symposium will consider nuclear aspects of atmospheric and space systems for manned and/or unmanned space travel. Further information is available from Eldred L. Burkhard, Chairman, North Texas Section, American Nuclear Society, Convair Div., Fort Worth, Texas.

April 5-7—

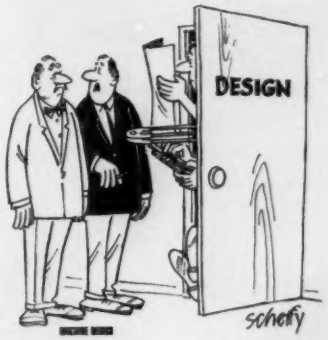
Engineering Institute on Statistical Quality Control Appreciation to be held at the University of Wisconsin. Additional information can be obtained from Engineering Institutes, 3030 Stadium, University of Wisconsin Extension, Madison 6, Wis.

April 11-12—

Seminar on Engineering Standards: Procedures, Practices, and Problems to be held at the University of Wisconsin. Further information is available from Engineering Institutes, 3030 Stadium, University of Wisconsin Extension, Madison 6, Wis.

April 17-19—

Seventh National Symposium on Instrumental Methods of Analysis, to be held at the Shamrock-Hilton Hotel, Houston. Sponsor is the Instrument Society of America; additional information is available from Meetings Services Dept., ISA, 313 Sixth Ave., Pittsburgh 22, Pa.



"We've just got to have more room, J.B."

April 17-21—

Short Course on Strain Gage Techniques, sponsored by the Society of Experimental Stress Analysis and Southwest Research Institute, to be held at the Granada Hotel, San Antonio, Texas. Emphasis will be placed on high and low-temperature applications, and lectures will be supplemented by labo-

(Please turn to Page 48)

Abrasion resistance approximately 25% better than carbon steel

CHEMICAL ANALYSIS AND PHYSICAL PROPERTIES

YOLOY GRADE A

Ladle Chemical Analysis, *percent*

Carbon	.25 max.	Sulphur	.050 max.
Manganese	1.60 max.	Silicon	.30 max.
Phosphorous	.040 max.	Copper	Optional

Minimum Physical Properties

THICKNESS	To 5/16"	Over 5/16" to 3/8" incl.	Over 3/8" to 1/2" incl.
Yield point, psi	50,000	47,000	45,000
Tensile strength, psi	70,000	70,000	70,000
Elongation in 2", %	20.0	20.0	20.0

YOLOY GRADE B

Ladle Chemical Analysis, *percent*

Carbon	.23 max.	Sulphur	.050 max.
Manganese	1.40 max.	Silicon	.30 max.
Phosphorous	.040 max.	Copper	.20 min.

Minimum Physical Properties

THICKNESS	To 1/2" incl.	Over 1/2" to 1½" incl.
Yield point, psi	45,000	42,000
Tensile strength, psi	70,000	65,000
Elongated in 2", %	22.0	22.0

ADDITIONAL TYPICAL PROPERTIES OF YOLOY GRADE B

Ultimate compressive strength.....equals tensile strength
Ultimate shearing strength..equal to ¾ tensile strength
Modulus of elasticity, psi.....28,000,000/30,000,000
Endurance limit (normalized), psi.....40,000
Charpy impact, keyhole notch
(As rolled room temperature, av. ft. lbs.).....30
Coefficient of expansion, per degree F.
70° to 200° F..... .0000063

FABRICATING PRACTICE FOR COLD FORMING

Thickness of product	Recommended minimum inside Radii	
	Yoloy Grade A	Yoloy Grade B
1/16" to 1/4" incl.	2-½ x thickness	2 x thickness.
Over 1/4" to 1/2" incl.	3-½ x thickness	3 x thickness.

Hot forming is recommended for thicknesses over 1/2"

WELDING Yoloy M may be butt welded satisfactorily using the low hydrogen electrode without preheat. Similar results were obtained on fillet welds. The parent metal failed before the weldments.

YOLOY

high strength steel outlasts ordinary steels—makes tough equipment tougher

Youngstown's Yoloy M is a special steel for punishing jobs. It is a giant shovel's bucket teeth, bulldozer blades, tracks for cats. A steel to stand up under weather and wear. Yet Yoloy M costs less in the long run because it outlasts others.

Yoloy M is a low carbon open hearth steel alloyed with precise amounts of copper and manganese. It resists atmospheric corrosion up to 2 times better than carbon steels—is up to 40% stronger. You replace weight with strength. You get a tougher, harder steel to keep heavy equipment working longer under any and all conditions.

Youngstown makes Yoloy M in two different types to suit your specifications: Grade A and Grade B. Yoloy Grade A is recommended for light plate and intermediate thickness applications where only moderate forming and simple welding are involved. Yoloy Grade B is for special applications involving intricate forming and greater resistance to shock and impact. Both are available in hot rolled bars, bar shapes, plates, sheets and strip.

Specify high quality Youngstown Yoloy M when you want rugged, efficient higher strength steel.

Youngstown – growing force in steel

For complete information about Yoloy Steel, write: Department 3-A.
The Youngstown Sheet and Tube Company, Youngstown, Ohio

Circle 423 on Page 19

SAVE SPACE and REDUCE COSTS

with

AURORA®

VERTICAL END-SUCTION PUMPS

Capacities to 1800 GPM
Heads to 320 Feet

This close-couple, vertical mounting design provides the extreme compactness that is so important for the many applications where space allocation is critical. Flanged suction mounting cuts piping costs by direct mounting to tank. Separate foundation arrangement is eliminated along with any alignment problems. Optional discharge arrangement permits the most simplified installation.

The many desirable features of the Horizontal End Suction Pumps are retained . . . motor and rotary assembly easily removable without disturbing the suction or discharge piping . . . low NPSH . . . smooth quiet operation. Available in vertical base mounting design as well as close coupled or flexible coupled horizontal models.

WRITE TODAY FOR BULLETIN

AURORA Always PUMPS

AURORA PUMP DIVISION
THE NEW YORK AIR BRAKE COMPANY
800 LOUCKS • AURORA, ILLINOIS
LOCAL DISTRIBUTOR IS LISTED IN THE YELLOW PAGES OF YOUR PHONE BOOK

(Continued from Page 45)

ratory work. Additional information can be obtained from Dr. M. M. Lemcoe, Southwest Research Institute, P. O. Box 2296, San Antonio 6, Texas.

April 18-19—

Process Planning-Operations Research Seminar to be held at the Statler Hilton Hotel, Cleveland, under the sponsorship of the American Society of Tool and Manufacturing Engineers. Further information is available from ASTME headquarters, 10700 Puritan Ave., Detroit 38, Mich.

April 18-19—

Engineering Institute on Nomography to be held at the University of Wisconsin. Additional information can be obtained from Engineering Institutes, 3030 Stadium, University of Wisconsin Extension, Madison 6, Wis.

April 30-May 4—

Aero-Space Instrumentation Symposium, sponsored by Instrument Society of America, to be held at the Adolphus Hotel, Dallas. Further information is available from W. J. Gabriel, Group Engineer, Convair Div., General Dynamics Corp., Ft. Worth, Texas.

May 8-9—

Lubrication Symposium, sponsored by American Society of Mechanical Engineers, to be held at the Deauville, Miami Beach, Fla. Additional information is available from ASME Meetings Dept., 29 West 39th St., New York 18, N. Y.

May 8-10—

Fourth National Power Instrumentation Symposium, sponsored by Instrument Society of America, to be held at the La Salle Hotel, Chicago. Additional information can be obtained from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

May 9-10—

Engineering Institute on Product Development to be held at the University of Wisconsin. Additional information can be obtained from Engineering Institutes, 3030 Stadium, University of Wisconsin Extension, Madison 6, Wis.

Circle 424 on Page 19

SILICOLOGY *Studies in Silicones*

HOW THESE TIME-TESTED MATERIALS CAN WORK FOR YOU

As the Jets Go Faster, Hotter... Silicones Match Their Needs

Just a few years ago, silicones were "wonder chemicals of the future." Today, their future is here. In the aviation industry they are firmly established as reliable materials of jet age technology and engineering, with properties unattainable in any other practical way.

The applications of UNION CARBIDE Silicone Rubber, for example, have multiplied steadily. First used to make bomb bay door seals that would stay flexible in the intense cold of high altitudes, silicone rubber extruded shapes are now standard equipment on both military and commercial jets where lasting reliability is a basic requirement.

FROM RADIOS TO OXYGEN MASKS

Sensitive aircraft radar, radio, and other electronic equipment is designed today with much of its wiring insulated with silicone rubber. Flexible from far below zero to several hundred degrees F., it is resistant to ozone, light, and chemicals, and has excellent electrical properties.

Soft, lightweight, flexible silicone rubber oxygen masks for both passengers and crew are now regular equipment for airlines and military alike.

Jet engine hot-air starter hoses containing silicone rubber are equally at home in the arctic or tropics. They resist searing heat with a reliability that is unmatched by any other material. And silicone rubber's thermal resistance plus its low compression set have gained, for it, widespread aviation use in O-rings, grommets, washers and boots.

VITAL TO GLASS FIBER PANELS

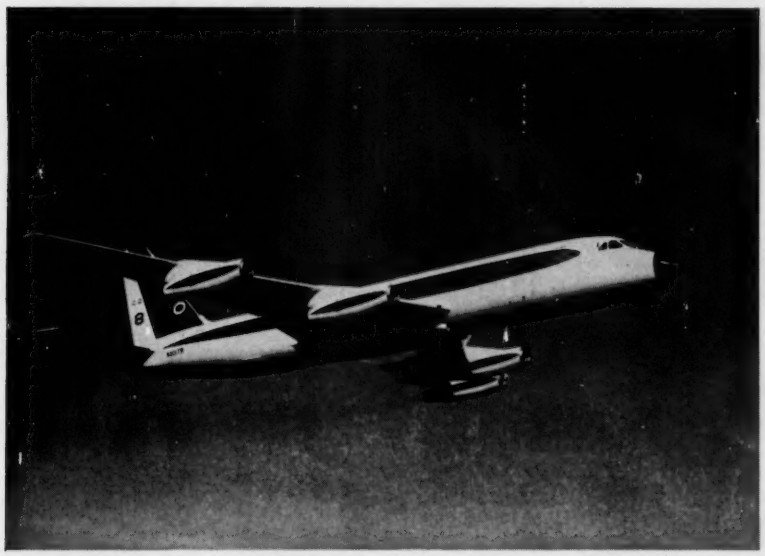
There are more and more places in modern jets where light, tough, glass-fiber-reinforced plastic panels and shapes serve yeoman duty. In cabin walls, partitions, radomes, tail-cones, instrument panels, fairings, to name a few. In many of these, a UNION CARBIDE silane plays a strong role. Applied to the fibers, it unites them chemically with the plastic. Thus it keeps moisture from penetrating between these vastly unlike materials, preserving panel strength and extending its working life spectacularly.

And today UNION CARBIDE Silicone Resins are in growing demand for high-temperature paint systems to insure maintenance of smooth protective surfaces on the wings and bodies of supersonic jets.

Among the varied uses of UNION CARBIDE Silicone Fluids there is one that ranks them in importance with rubbers and resins. For without this all-temperature, constant-viscosity damping fluid in instrument needle-shaft bearings, these delicate devices would be far less reliable . . . and safe. Another very important factor is that silicone fluid's extremely high compressibility allows damping devices to be of smaller size.

RE-APPRAISE YOUR OWN NEEDS

In the aircraft industry, especially, technology and development are changing more rapidly than ever before. Perhaps you are overlooking a good bet—some place in the design of your products where silicones can serve you, improving quality at surprisingly low cost. Send the coupon for further information.



CONVAIR 880 JET TRANSPORT. Silicones contribute in many ways to the reliability of this new high-performance aircraft.

UNION CARBIDE

SILICONES

UNION CARBIDE is a registered trade mark of Union Carbide Corporation.

Silicones Division
Union Carbide Corporation
Dept. CL-0101
270 Park Avenue, New York 17, N. Y.

In Canada: Union Carbide Canada Ltd., Bakelite Division, Toronto 12.

Please send me data on_____

_____

NAME_____

TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE___ STATE_____

Circle 425 on Page 19

Is your secretary better equipped than your engineers or draftsmen?

She deserves the best, bless her, and often gets it—but your skilled *draftsmen*, too, need today's tools to cope with today's demands.

Your draftsmen, your productivity, deserve new Hamilton space-and-time-saving equipment — from Dietzgen

Even your most efficient and productive men turn out better work with high-quality, professionally designed drafting equipment. They will accomplish more, make fewer errors and be far less fatigued when they work with Hamilton professional equipment. Basic Hamilton design gives your engineers or draftsmen new capacity for increased efficiency and improved morale. Our designers will help plan your individual needs.

HAMILTON DELUXE AUTO-SHIFT TABLE This unit combines modern styling with advanced features to create top efficiency. It greatly reduces fatigue, helps your men achieve the highest quality in draftsmanship and maximum production. Fully seasoned drawing surface is adjustable to individual height and slope requirements, providing complete board accessibility that reduces errors. Fast, simple adjustments. Unusually durable and handsome in appearance.

Hamilton Unit System Files
Provide full protection, accessibility, and classification for all materials to be filed. Occupy minimum floor space.

Hamilton L-Contour Table
Prestige-assured, individualized work area providing complete board adjustment plus extra storage and reference area.

Hamilton CL 100 Drafting Table
Conserves dollars, yet rugged canted-leg design provides modern styling and convenience with long-term durability.

Drafting-Printmaking Booklet reports new techniques for solving engineering and production problems

This new 36 page booklet describes a wide variety of engineering and production problems that have been solved with advance techniques in drafting and printmaking pioneered by Dietzgen. The concise, problem-solution approach suggests ways in which you may improve the efficiency within your engineering department or eliminate production bottlenecks. Write today on your company letterhead for the Mechanics of Modern Miracles. Ask for Publication SPD2-A10. Eugene Dietzgen Co., Chicago 14, Illinois

DIETZGEN

EVERYTHING FOR DRAFTING SURVEYING & PRINTMAKING

PRINCIPAL OFFICES: CHICAGO · SAN FRANCISCO

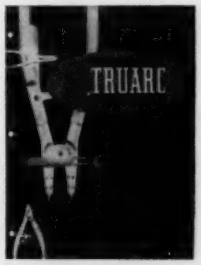
NEW YORK · NEW ORLEANS · LOS ANGELES · CALGARY

SALES OFFICES AND DEALERS IN ALL PRINCIPAL CITIES

Circle 426 on Page 19

Truarc self-locking rings replace other fasteners . . . eliminate tapping of casting on this tiny tape recorder. Result: MOHAWK BUSINESS MACHINES CORP. increased production 60% and sharply reduced assembly costs.

PRODUCTION PROPOSITION: Find out how a Truarc Engineer can help you eliminate *unnecessary* production steps and tools. Get his estimate of the savings you can expect in time, money and material on the *final* assembled cost of your product. Our Catalog AT 10-58 shows the complete line of Truarc Rings and assembly tools. Send for your copy today. For immediate action call your nearest **Authorized Truarc Distributor.** He's as close as your Classified Telephone Directory. Look under: "Rings, Retaining." o.9



WALDES TRUARC® RETAINING RINGS

WALDES KOHINOOR, INC., 47-16 Austel Place, Long Island City 1, N. Y.

9 OUT OF 10 PRODUCTS CAN BE IMPROVED WITH TRUARC RETAINING RINGS

© 1960 WALDES KOHINOOR, INC.

Why design to a proprietary standard?

Compare overall stack heights shown in the table below, and you'll see what we mean. Listed are so-called "standard" heights of ¼" 3-ring fabricated "V" packings offered by six major manufacturers. Overall heights range from a low of ⅝" up to 1 9/64" high . . . *a variation of more than ½".*

COMPARATIVE STACK HEIGHT OF FABRICATED "V" PACKINGS PLUS ADAPTER NOW OFFERED

C/S	SOURCE	3/SET
¼"	Mfgr. A	25/32
	" B	41/64
	" C	1 9/64
	" D	45/64
	" E	5/8
	" F	23/32

This means that in laying out a gland for fabricated "V" packings, the designer must first determine which manufacturer he wants to buy from before he completes his design. And once the gland is made for this particular brand of packing, replacements of the same brand are almost mandatory. Another handicap—switching to a leather or homogeneous packing later would be extremely difficult because of the difference in stack heights.

The use of Standard J.I.C. stack heights for fabricated "V" packings is the obvious answer to this problem. Yet, today Houghton is the only packing manufacturer who offers you uniform stack heights for *all three* major "V" packing materials—fabricated, homogeneous and leather—making them interchangeable with respect to dash number, O.D., I.D. and stack height.

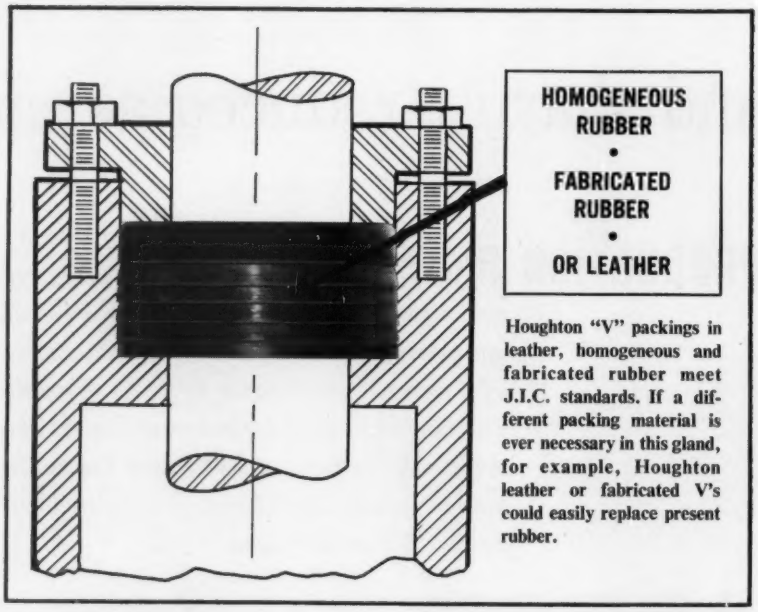
With Houghton "V" packings, you don't have to compromise in material to meet your operating requirements. Simply select the material best suited to the job and you know it will fit automatically.

Complete interchangeability among Houghton leather, rubber, and fabricated "V" packings is the solution to a long-standing problem —the choice of material for an application that demands properties no single packing material can provide.

Now, the identical stack heights of all Houghton V's permit *unlimited* switching of V combinations in any gland, either with rings of the same material, or different materials within a set.

You can use a leather V for anti-extrusion, strength, and low friction with rubber rings for wiping efficiency and low cost. You can switch from homogeneous rubber to fabricated to gain extra strength. You can even use V's of all three materials in the same gland.

Leadership in packing standardization is another reason major hydraulic and pneumatic equipment manufacturers consider Houghton "packing headquarters". Houghton is also the only manufacturer who offers a *complete* line of packings and fluids for almost any industrial hydraulic system. This experience in both fields is your guarantee of a completely unbiased recommendation of compatible materials . . . the very best for your particular application. For more information or help, call or write: E. F. Houghton & Co., 303 W. Lehigh Ave., Phila. 33, Pa.



Houghton "V" packings in leather, homogeneous and fabricated rubber meet J.I.C. standards. If a different packing material is ever necessary in this gland, for example, Houghton leather or fabricated V's could easily replace present rubber.

Houghton

INDUSTRY'S PARTNER IN PRODUCTION

Circle 428 on Page 19

SINGER* NUMERICAL CONTROL

The Singer Numerical Control System represents the most direct approach to point-to-point positioning yet conceived. It offers simplicity, reliability and economy, reducing costs of maintenance, labor and downtime.

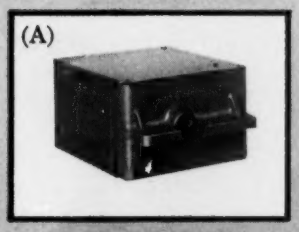
A major feature of Singer automation is modular design. This makes it possible to assemble basic units in a variety of control systems.

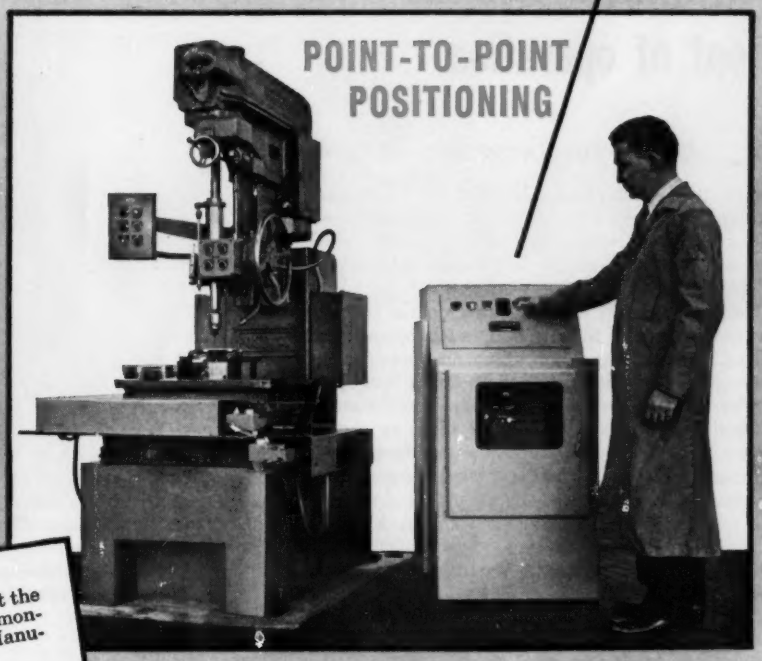
AUTOMATIC POSITIONING SYSTEM

For example, because of the simplicity of Singer modular design, an Automatic Positioning System can be furnished immediately as standard for use on a drilling machine to drive and position the work table and saddle motion.

All that is required is a motor drive assembly (A) and a position indicator control (B) on each axis. This system will then operate with standard end measures.

At any future time, tape control can easily be added to provide a complete Singer Numerical Control System, as shown below with a Fosdick 5BM Sensitive Drill Press.



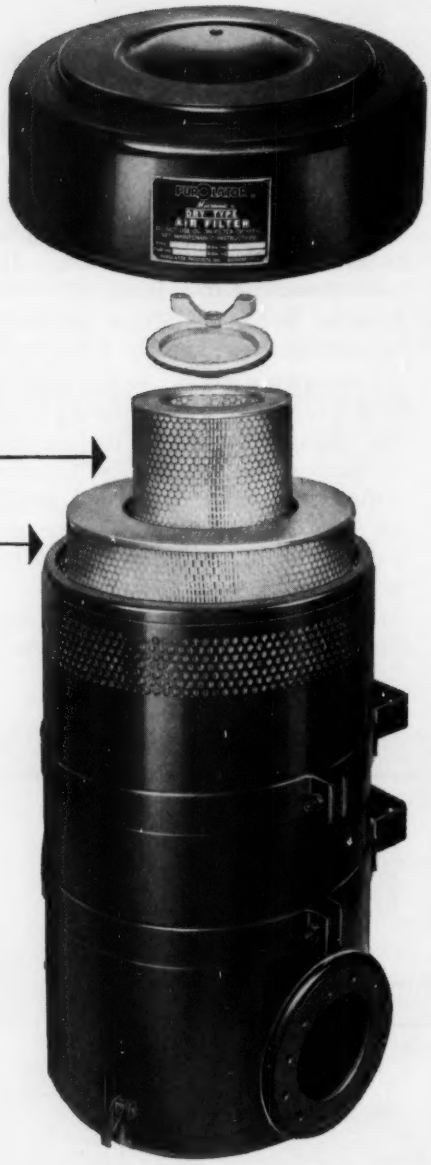


AN INVITATION
You are cordially invited to visit the Singer Numerical Control demonstration room at the Diehl Manufacturing Company

Diehl†

DIEHL MANUFACTURING COMPANY
SUBSIDIARY OF THE SINGER MANUFACTURING COMPANY
Finderne Plant, Somerville, New Jersey
Telephone: Randolph 5-2200

*A Trademark of THE SINGER MANUFACTURING COMPANY
†A Trademark of THE DIEHL MANUFACTURING COMPANY



an element here

and an element here

assures 99.98% filtration efficiency even when 1 element is out of operation

IT'S THE NEW PUROLATOR TWO-STAGE FILTER

Simplicity of design makes the first cost of Purolator's new dry-type two-stage filter as low as any two-stage filter on the market. Each element filters independently, and together they dustproof your engine as no other filter can . . . 99.98% efficient.

Users save money and get better engine protection from this new Purolator filter, too. The first stage element will last up to 2000 hours, depending on operating conditions. The second stage will usually last almost indefinitely if the first element and sealing gaskets are maintained properly.

Another big user-advantage is the way the two-stage design protects the engine despite accidental mishandling of the element. Even if the first stage element is damaged, the chance of harming the engine can be discounted when it is protected with the second stage back stop element. In addition, the second stage element lets the operator service the unit in the field, regardless of how dusty the conditions are.

Both elements filter uniformly, in depth, over their whole surface, because they're both precision made of plastic impregnated cellulose. This series of two-stage filters is rated from 450 to 1150 cfm, with exceptionally low initial restriction. Mounting straps, rainhoods and outlet adapters are available.

For more information write to Purolator Products, Inc., Department 3896, Rahway, New Jersey.

Purolator Products, Inc.
Dept. 3896, Rahway, New Jersey

Please send me complete data on the new Purolator two-stage filter series.

Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

Filtration For Every Known Fluid

PUROLATOR

PRODUCTS, INC.

RAHWAY, NEW JERSEY AND TORONTO, CANADA

Circle 430 on Page 19

Look to

FAFNIR

for leadership in ball bearings

Where cost is your problem...

Costs can nip good design ideas in the bud. Fafnir helps cut costs with Flangette Units. Millions of these ball bearing "economy packages" — a Fafnir "first" — are used to improve performance and reduce maintenance on products ranging from small conveyors to giant combines. When you're up against costs... or *any* bearing problem . . . look to Fafnir. The Fafnir Bearing Company, New Britain, Connecticut.

50 YEARS OF EXPERIENCE
IN THE MANUFACTURE OF
BALL BEARINGS

FAFNIR
BALL BEARINGS

Circle S-251

Look to

FAFNIR

for leadership in
ball bearings

Where dirt is your problem...

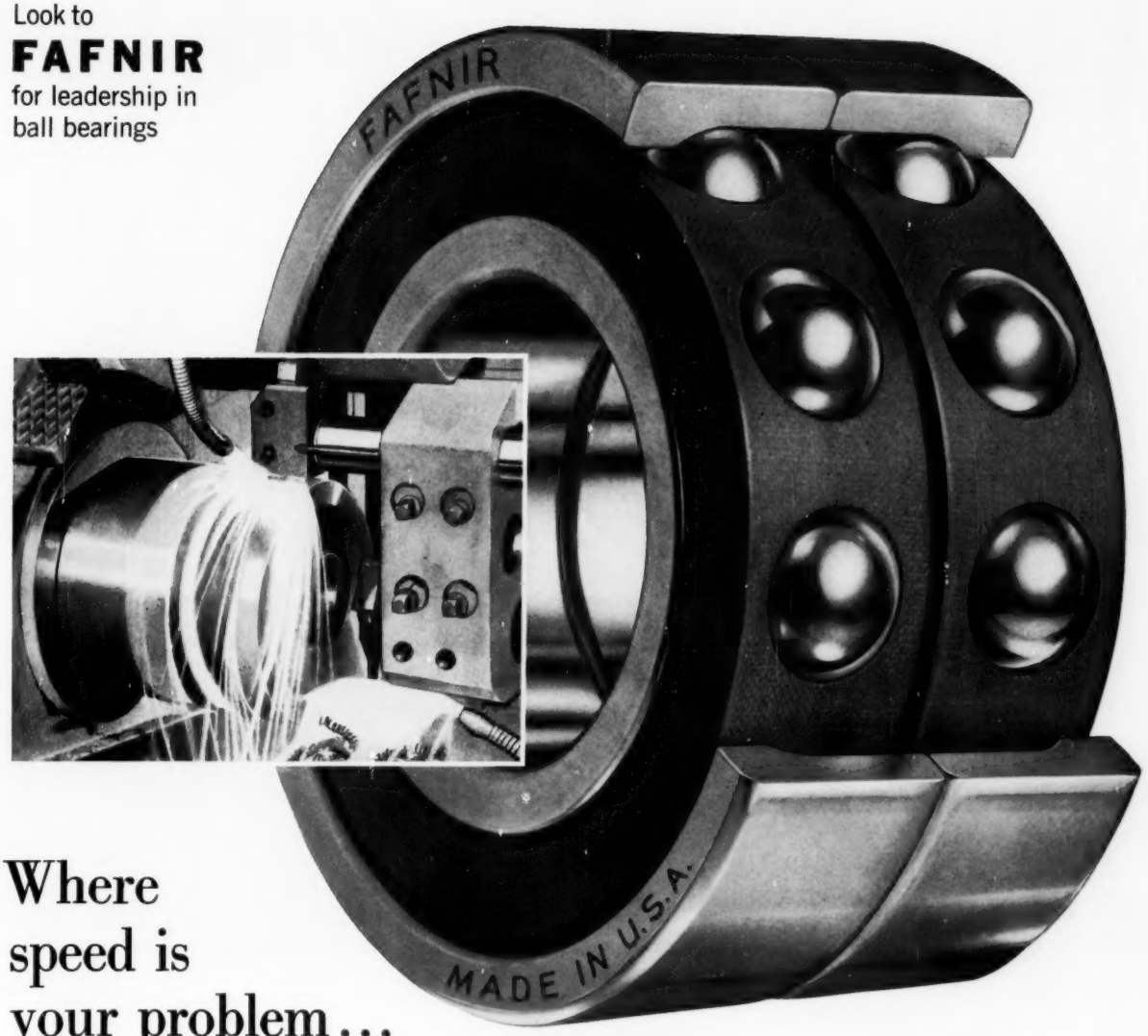
Dirt is cheap . . . but not when it gets into bearings. It handicaps production . . . runs up costs . . . shortens product life. How to keep dirt out? Disc harrow makers do it with Fafnir Ball Bearings . . . triple-sealed to "run clean" where it's dirtiest. When you're up against dirt . . . or *any* bearing problem . . . look to Fafnir for the diversity, the capacity, the research to find your answer. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR

BALL BEARINGS

Circle S-252

Look to
FAFNIR
for leadership in
ball bearings



Where speed is your problem...

Today's high speeds put the spotlight on bearings. For when bearings fail, costs rise . . . and profits drop. Machine tool builders know this. That's why they specify Fafnir Ball Bearings for high speed applications — 100,000 rpm and up. So, when you're up against speed . . . or *any* bearing problem . . . look to Fafnir for the diversity, the capacity, and the research to find your answer. The Fafnir Bearing Company, New Britain, Connecticut.

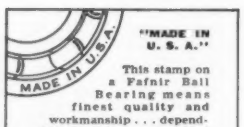
FAFNIR
BALL BEARINGS

Circle S-253

Look to
FAFNIR
for leadership in
ball bearings

Where heat is your problem...

Some bearings "freeze" under prolonged high heat. When they do, performance drops off . . . costs rise . . . and the heat's on *you!* The answer? Fafnir Ball Bearings engineered for high temperature service. For instance, in the X-15 manned rocket, they're used by the hundreds at critical points. So, when you're up against heat . . . or *any* bearing problem . . . look to Fafnir for the diversity, the capacity, the research to find your answer. The Fafnir Bearing Company, New Britain, Connecticut.

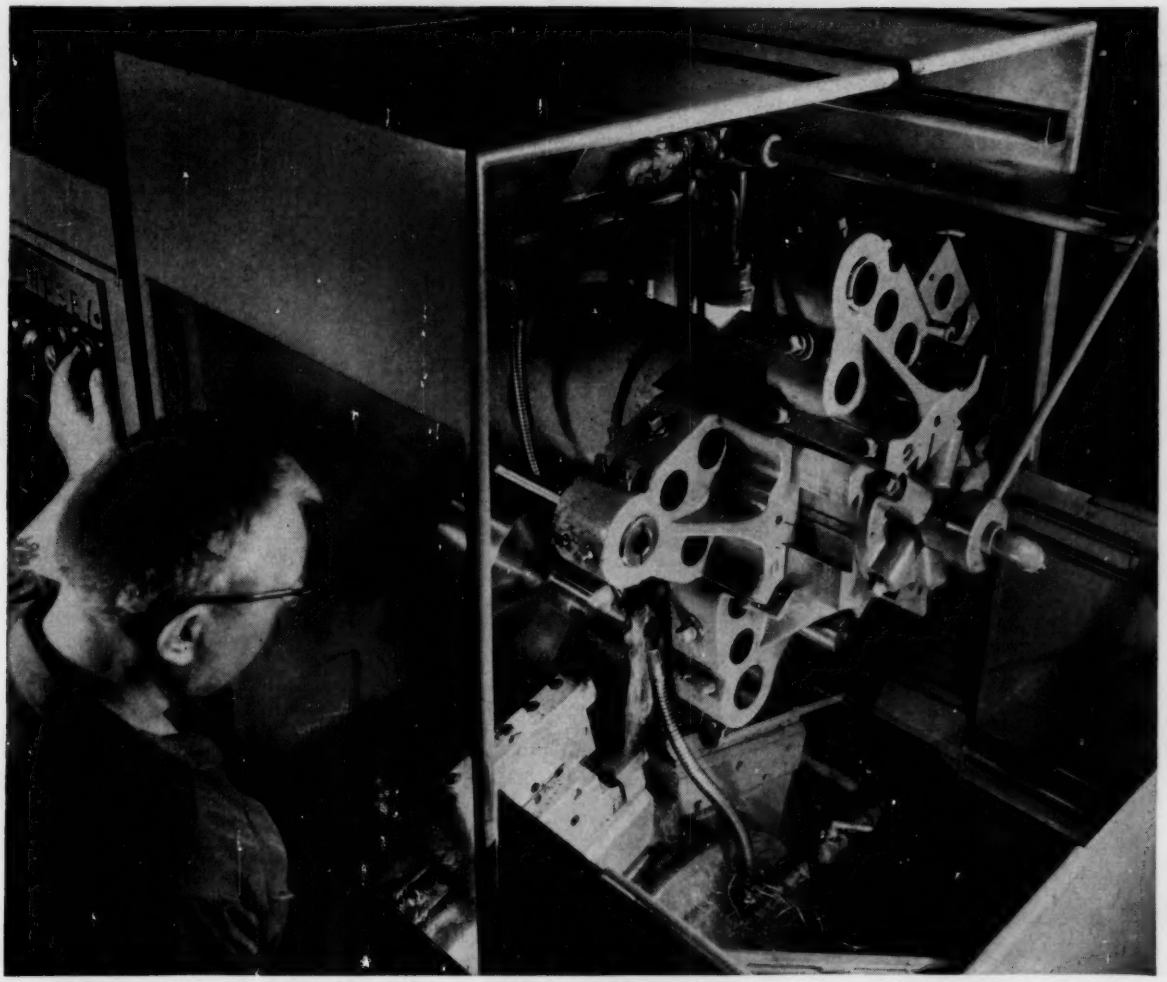


"MADE IN U. S. A."

This stamp on a Fafnir Ball Bearing means finest quality and workmanship . . . dependable supply . . . competent engineering help . . . and **responsibility** in meeting your bearing needs. It's worth bearing in mind.

FAFNIR
BALL BEARINGS

Circle S-254



Rigidity and accuracy built into this Warner & Swasey 2AC chucking automatic permit heavy metal removal while holding close tolerances. Twenty-one parts made from AISI 4340 and 4615/20 steels contribute resistance to stress and wear in critical areas.

Warner & Swasey uses two nickel alloy steels to give the 2AC built-in rigidity and accuracy

Variety of parts made from 4340 and 4615/20 for long-term resistance to impact and wear.

Here's where the Warner & Swasey Company relies on AISI 4340 and 4615/20 to help maintain the rigidity and accuracy for which this 2AC single spindle chucking automatic is fast becoming famous.

Four clutch plates, for example, are made of 4340. Through-hardened for these parts, this 1.85% nickel steel provides dimensional stability in heat-treatment and in high-temperature operation . . . in addition to vital resistance to shock-loading and torsion.

Shafts, guide blocks, studs, plungers, and clamp strips are just a few of the parts in the versatile 2AC made from another nickel alloy steel: AISI 4615/20. These components are carburized and hardened for wear-resistance to maintain accuracy throughout a long service life. And the *uniform* hard case is backed up by a strong, tough core that stands up to severe impact and torsional stresses.

This report is typical of the many coming in from manufacturers who have employed these two General Purpose Steels for a variety of machinery components.

Both these steels are readily available, right off the shelf at your local Steel Service Center. Together they give you a double-barreled way to cut costs and still satisfy almost all your alloy steel needs. Other nickel alloy steels, possessing special properties for specialized applications, are also widely available.

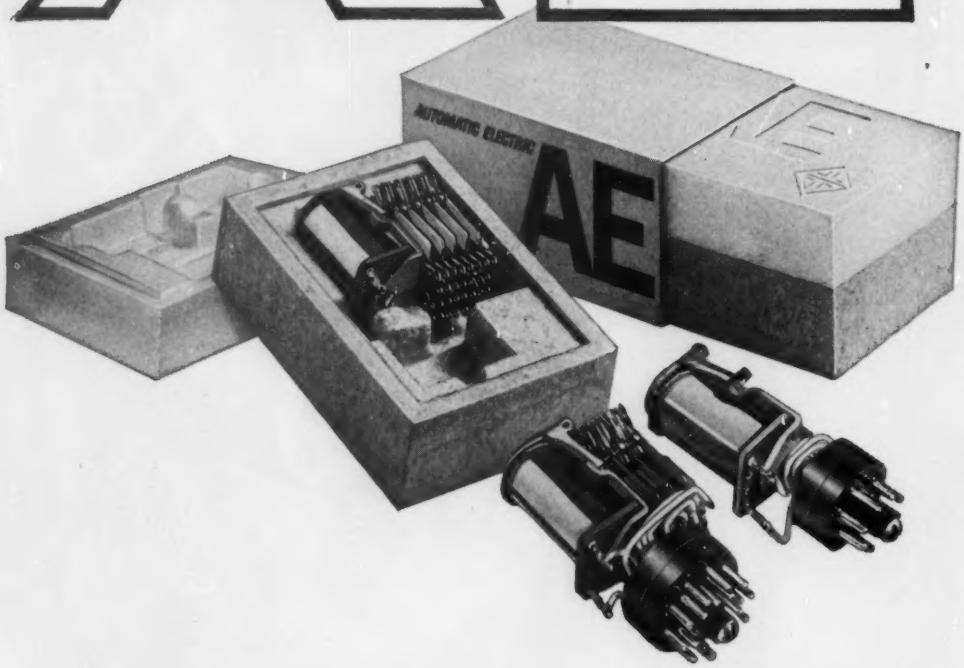
Consider nickel alloy steels for gears, shafts, bearings, and other machine parts you design, order, or use. And for engineering information to help you select the right material for the job you have in mind, just write to Inco.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

NICKEL MAKES STEEL PERFORM BETTER LONGER

AE



TO THE ENGINEER

who wants his "circuit jewelry" intact

AE takes great pains in preparing its Class E relays for a well-adjusted life in the world of automatic control. To make sure that they reach you in the same happy state, we're now shipping them in a special protective package molded to shape from featherweight polystyrene foam.

The two sections of the case have identical multiform cavities. When put together, they form a snug fit for any Class E relay assembly. The possibility of relay damage in packing, in transit or in removal is virtually eliminated. To facilitate production, the containers can be fed directly to your assembly line; relays remain protected and accessible.

As for Class E relays, you can have them with the usual solder terminals, "Taper-Tabs," end-mounted printed circuit terminals, wire-wrap, prewired octal plugs, screw terminals or other special forms to fit your needs.

Our circuit engineers will be happy to work with you in applying Class E relays to your designs. They'll also be glad to tackle any control problems you may have.

Want details? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. And be sure to ask for Circular 1702-E, "Relays for Industry."

AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

Swagelok®

BULKHEAD CONNECTIONS

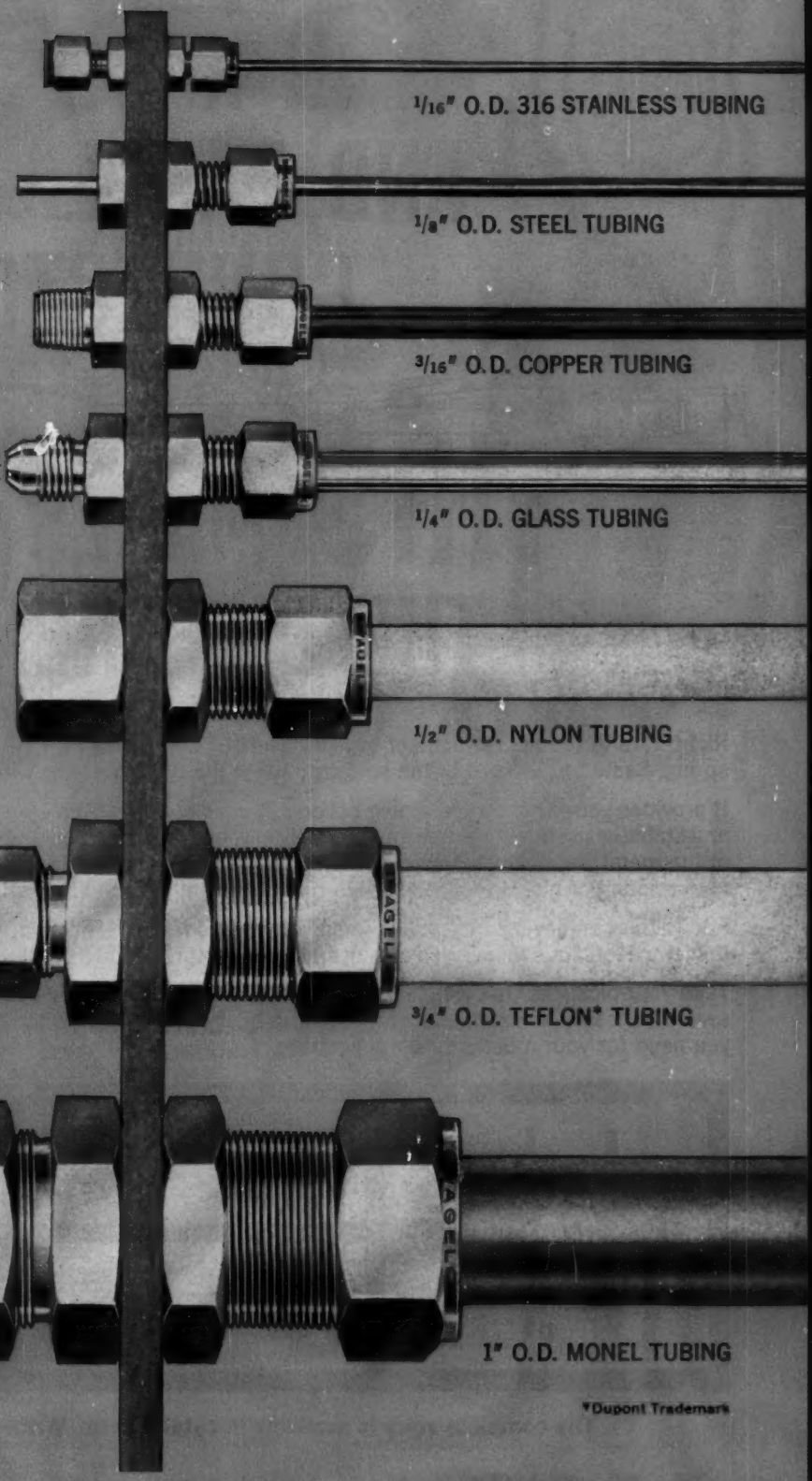
Only Swagelok has such a complete variety of Bulkhead Tube Fittings. Standard Swagelok Bulkhead Tube Fittings include:

- Bulkhead Unions
- Bulkhead Adapters
- Bulkhead Male Connectors
- Bulkhead Swagelok to AN Unions
- Bulkhead Female Connectors
- Bulkhead Reducing Unions

Swagelok Bulkhead Fittings are available in sizes for 1/16" through 1" O.D. tubing and can make leak tight connections on a wide variety of tubing materials such as stainless steel, monel, Nylon, Teflon, glass, copper, steel, etc.

Swagelok Bulkhead Fittings, like all Swagelok Tube Fittings, are available in any machineable metal or plastic to meet your particular requirements.

Remember, whether you require fittings for the simplest application or the most demanding, whether it is unusual tubing material, unusual fitting material or unusual fitting types, Swagelok Tube Fittings solve your problem.


1/16" O.D. 316 STAINLESS TUBING
1/8" O.D. STEEL TUBING
3/16" O.D. COPPER TUBING
1/4" O.D. GLASS TUBING
1/2" O.D. NYLON TUBING
3/4" O.D. TEFLON* TUBING
1" O.D. MONEL TUBING

*Dupont Trademark

Swagelok® TUBE FITTINGS SOLVE YOUR PROBLEMS

CRAWFORD FITTING COMPANY • 884 EAST 140th STREET • CLEVELAND 10, OHIO
CRAWFORD FITTINGS (CANADA) LTD., NIAGARA FALLS, ONTARIO, CANADA

Circle 434 on Page 19

IN RACK AND PANEL CONNECTORS

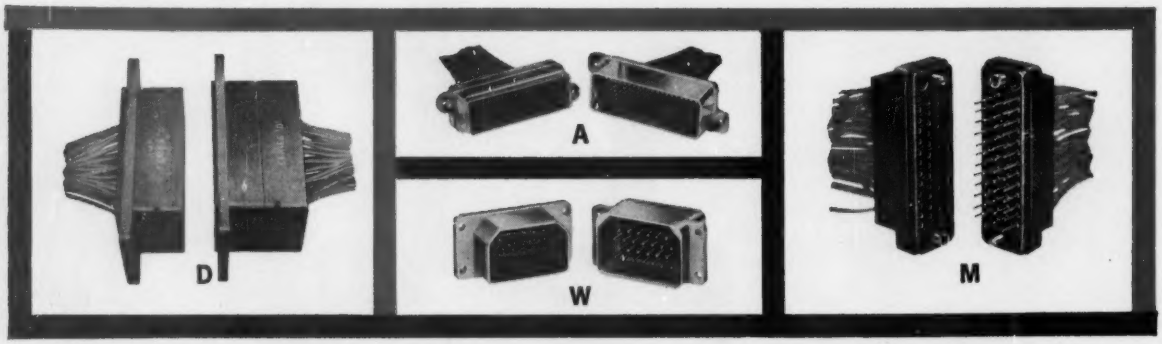
THIS MAKES THE DIFFERENCE!

Right here in the socket contact lies the heart of the **AMPin-cert Connector** line: the AMP cantilever spring. Seated in the slot of the socket to meet the pin shaft, it is your key to top connector reliability.

It provides you with positive wiping action . . . consistently sound electrical contact . . . firm pin grip . . . and stable resistance—yet has an extremely low, uniform insertion and withdrawal force. And, regardless of the metal plating you choose or the thickness you require, all pins and sockets are provided with an underplating of nickel to give long life reliability in all critical applications.

Add to this cantilever construction, many other plus features including AMP's industry proven solderless crimping technique to help you design and manufacture products of the highest reliability and lowest cost.

Take your pick: **AMPin-cert Connectors** in Series D, M and W as well as environmentally sealed or unsealed Series A—all tough enough to soak up heavy punishment while providing the dry circuit sensitivity you need for your most critical applications.



The complete story is available in catalog form. Write today for your copy.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • West Germany

WORKHORSE
OZALID'S
NEW PRINTMASTER
900

PRINTMASTER 900
Ht.—70½", Width—84¼", Depth—46½". Newest in Ozalid's family of whiteprinters... all designed to give you the finest reproduction at the lowest possible cost. Whatever your need there's an Ozalid whiteprinter to meet it.

Big volume of engineering prints? Put Ozalid's new Printmaster 900 to work. This new, heavy-duty whiteprinter is a workhorse for capacity, a thoroughbred for quality, a favorite for economy.

Fast! Top speeds up to 75 feet per minute. Versatile... processes any dry diazo material up to 42" wide without sticking. Develops both sides in one pass! Unique... new, sleeveless, scratch-proof developing and simplified control make it top performer in its price class.

Here, in truth, is a new concept in whiteprinting. New ideas, new designs from the leader in the industry that spell new efficiency, reliability, economy in engineering reproduction.

The coupon will bring you the facts on Ozalid's new "900". Facts that may save you thousands yearly. Mail it today.

OZALID®

Division of General Aniline & Film Corporation, Johnson City, New York

REMEMBER, FOR PEAK EFFICIENCY, ALL OZALID WHITEPRINTERS WORK BEST WITH OZALID SENSITIZED MATERIALS

Mr. James A. Travis, Mgr., Marketing
Ozalid, Dept. 211 Johnson City, New York

Please send information on New Printmaster 900.

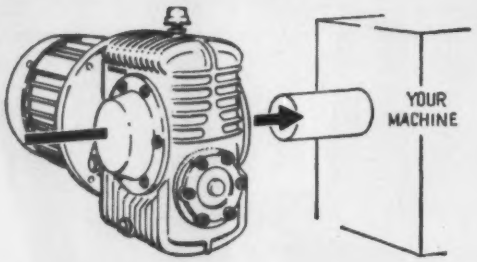
Name_____

Firm_____

Address_____

City_____

CONE-DRIVE GEARMOTORS for "PLUG-IN" POWER



Hollow-Shaft Speed Reducer-Motor forms complete power transmission package . . .

With the compact, right-angle Cone-Drive gearmotor the machine designer can make use of an integral drive package of nearly any required speed and horsepower. Twenty-seven standard output speeds from 7.3 to 525 RPM (with 1750 RPM motor) are available in models from ¼ to 40 horsepower. Gearmotors can be specified with hollow shaft for mounting in any position, ready to "plug-in". You can use this integrated power package to provide a simple, clean installation on your machine . . . no pulleys, belts, sheaves, bed plates, couplings, etc.

Electric motors are standard "D" flange type with slight shaft modification for driving helical primary reduction gears. Secondary reduction stage is a standard Cone-Drive double-enveloping worm gearset with maximum tooth engagement for greater load carrying capacity in smaller space.

Cone-Drive gearmotors are available for all AGMA service ratings. Call your Cone-Drive representative today or write for catalog #58 for complete specifications.

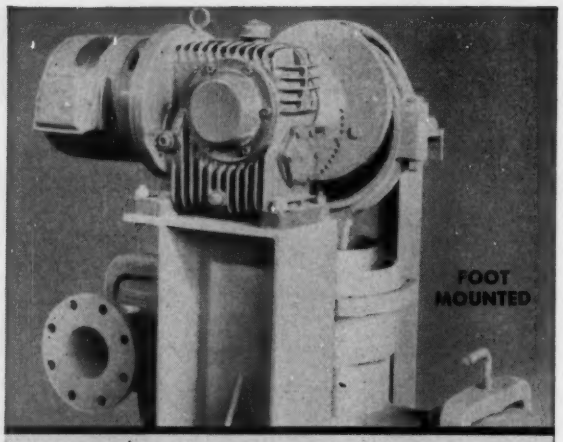
CONE-DRIVE GEARS
DIVISION MICHIGAN TOOL COMPANY
7171 E. McNichols Road Detroit 12, Michigan Telephone: TWinbrook 1-3111

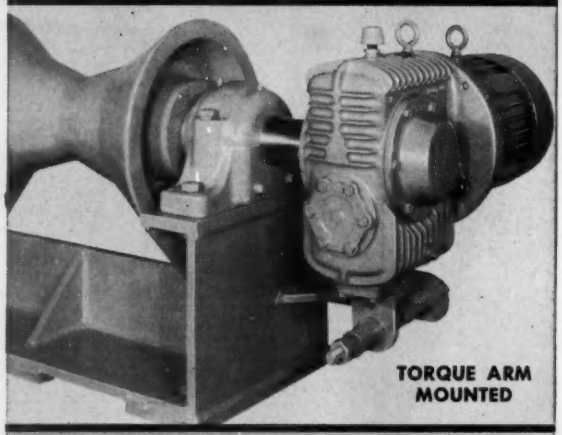
DOUBLE-ENVELOPING WORM GEARSETS

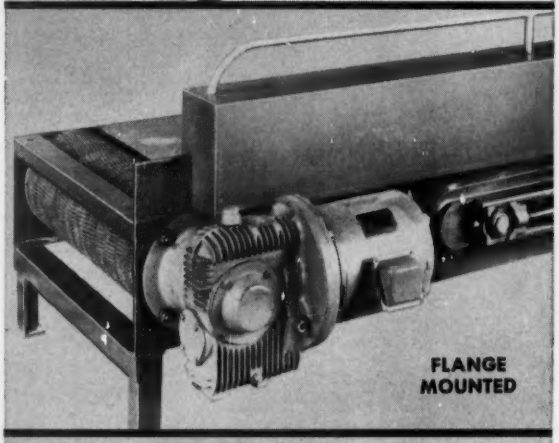
DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS

DOUBLE REDUCTION WORM GEAR SPEED REDUCERS

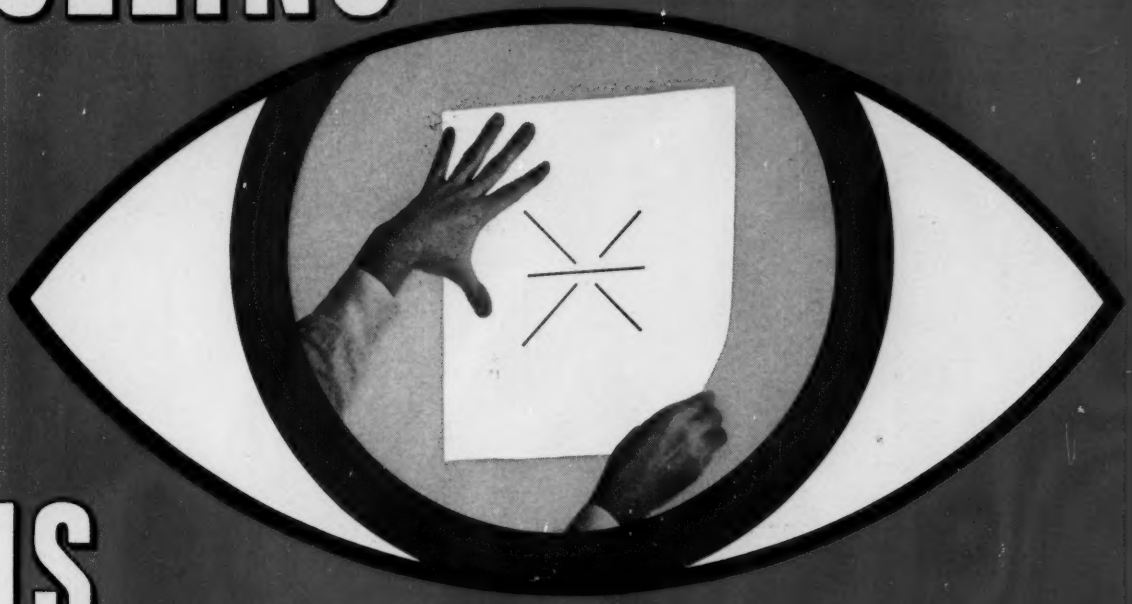
DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS

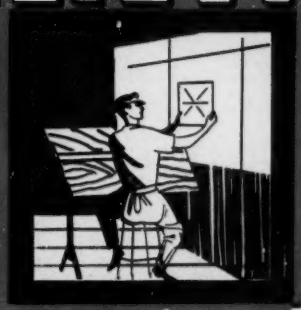






SEEING IS BELIEVING!





to prove it's best make the Clearprint test

See for yourself why leading engineers and architects demand Clearprint Technical Papers. Ask for a sample, then make this convincing test:

1. INVITES THE PENCIL
   Try Clearprint's perfect working surface with a 2H pencil, then with a ruling pen. Lines are sharp and clean—no feathery edges.
2. HIGHEST ERASING QUALITIES
   NO GHOSTING — Erase some of the lines. Redraw and erase several of them time and again. Crease the paper, too. Then hold it to the light, or make cleanest possible reproductions.
3. NEVER CHANGES
   Sheets in use for 27 years prove Clearprint's amazing stability. Its strength, transparency and printing qualities remain unchanged after extended exposure to age, atmosphere, heat and light. ITS COLOR DOES NOT CHANGE.

If you are not using Clearprint now, please make this comparative test on the paper you are using.

CLEARPRINT®

"FADE-OUT" PAPER T.M.
TECHNICAL PAPER
FORMS • CHARTS • GRAPHS
"PRE-PRINT" PAPER T.M.
THERE IS NO SUBSTITUTE
Clearprint is Watermarked For Your Protection

MD-1560

CLEARPRINT PAPER CO.
1482 - 67th St., Emeryville, Calif.

☐ Send me Clearprint Fade-Out samples, with prices, for the following uses:_____

Name_____

Firm_____

Address_____

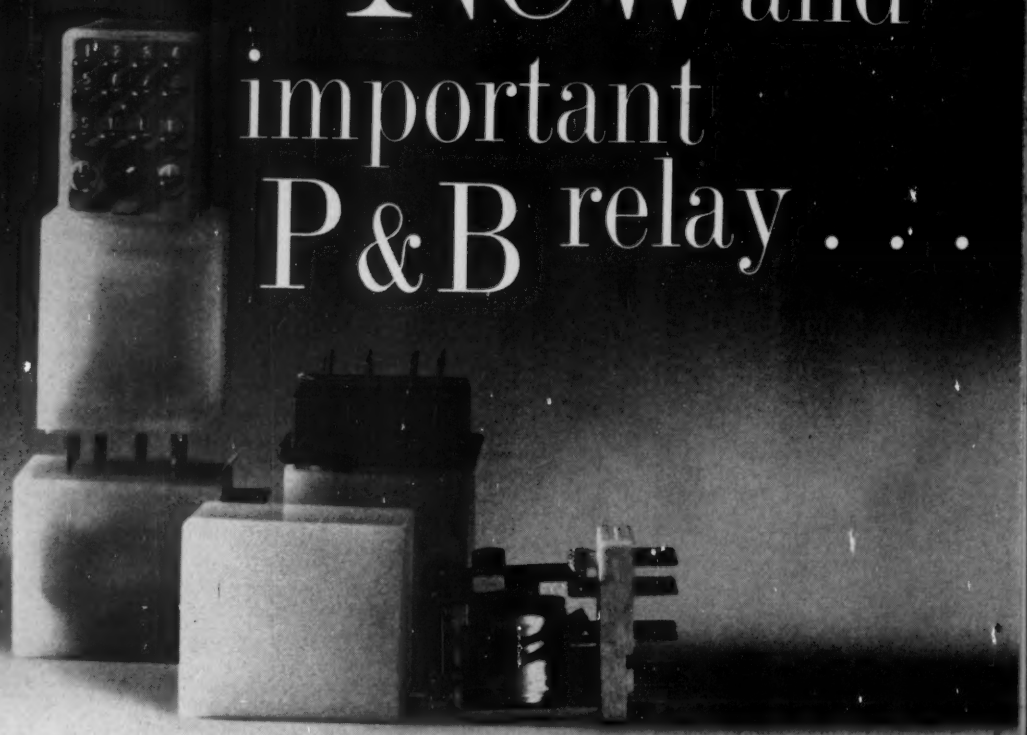
City_____ Zone___ State_____

S

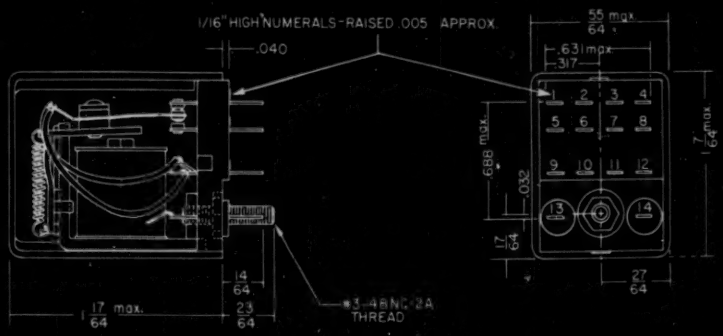
Circle 439 on page 19→

Circle 438 on Page 19

a New and important P&B relay . . .



KHP SERIES SHOWN ACTUAL SIZE



having rare longevity

This small, 4-pole relay has the happy faculty of maintaining its original operating tolerances over an exceptionally long life. Example: tests (by customers!) show this relay has variations in electrical characteristics of less than 5% after more than 100 million operations.

But that's far from all. This is a *small* relay . . . about a one inch cube. This relay is easy to install using the conveniently spaced solder lugs or a socket. Thus you save time and production costs. This relay is versatile . . . its 4PDT contacts will switch loads from dry circuit up to 3 amperes. This relay—well, why not order samples and see for yourself! Order today from your P&B representative or call us at Fulton 5-5251, in Princeton, Indiana.

KHP SERIES SPECIFICATIONS

CONTACTS:
Arrangement: 4 Form C, 2 Form Z.
Material: ½" dia. Silver standard. Silver cadmium oxide and gold alloy available.
Rating: 3 amps @ 30 volts DC or 115 volts AC resistive for 100,000 operations.

COILS:
Resistance: 11,000 ohms max.
Temperature: Operating Ambient: —45°C. to +70°C.
Power: 0.5 watts min. operate @ 25°C. 0.9 watts nom. @ 25°C. 2.0 watts max. @ 25°C.

TIMING VALUES:

Nominal Voltage @ 25°C.	Max. Values
Pull-in time	15 ms
Drop-out time	5 ms

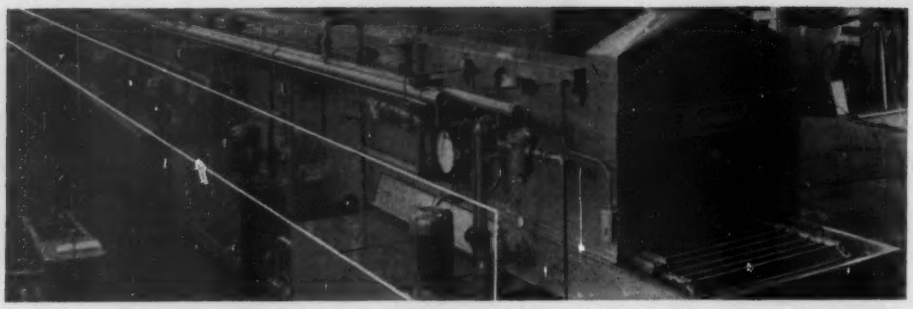
INSULATION RESISTANCE: 1500 megohms min.
DIELECTRIC STRENGTH:
500 Volts RMS 60 cycles between contacts.
1000 Volts RMS 60 cycles between other elements.
MECH. LIFE: In excess of 100 million cycles.
SOCKET: Solder lug or printed circuit terminals. Available as accessory.
DUST COVER: Standard.
TERMINALS: Solder lug and taper tab.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD, DIVISION OF AMF CANADA LIMITED, GUELPH, ONTARIO



Ingersoll-Rand solves pumping headaches . . .

You tell Ingersoll-Rand the liquid to be handled, the flow, temperature, pressure requirements and how you want to mount the pump — and I-R will furnish you with a unit to meet your exact needs.

In 100 years of pump manufacture, Ingersoll-Rand has solved many problems for machinery builders. For an economical solution to your liquid moving problems, call for the pump specialist at your nearest I-R branch office — or write direct to our New York headquarters. If we can't meet your requirements from our many standard models, we will engineer a unit just for you.

Immersion or sidewall units to 7½ HP for deliveries to 425 gpm, heads to 170 ft.

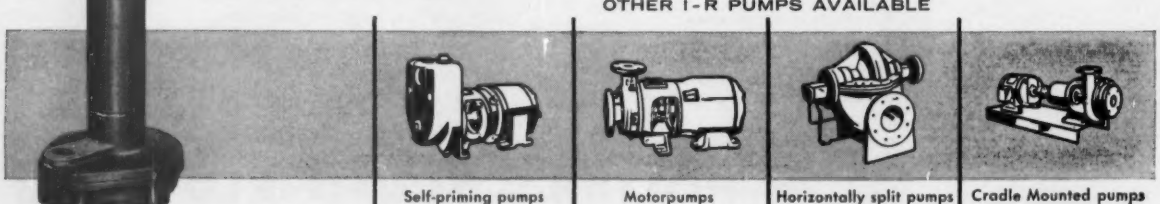
over a century IR *of pump progress*

from the leading manufacturer . . .

Ingersoll-Rand

B3A9 **11 Broadway, New York 4, N. Y.**

OTHER I-R PUMPS AVAILABLE



Self-priming pumps | Motorpumps | Horizontally split pumps | Cradle Mounted pumps

Circle 440 on Page 19

National Acme's SL2X limit switch

doubly certified

explosion proof

SWITCH SHOWN ACTUAL SIZE

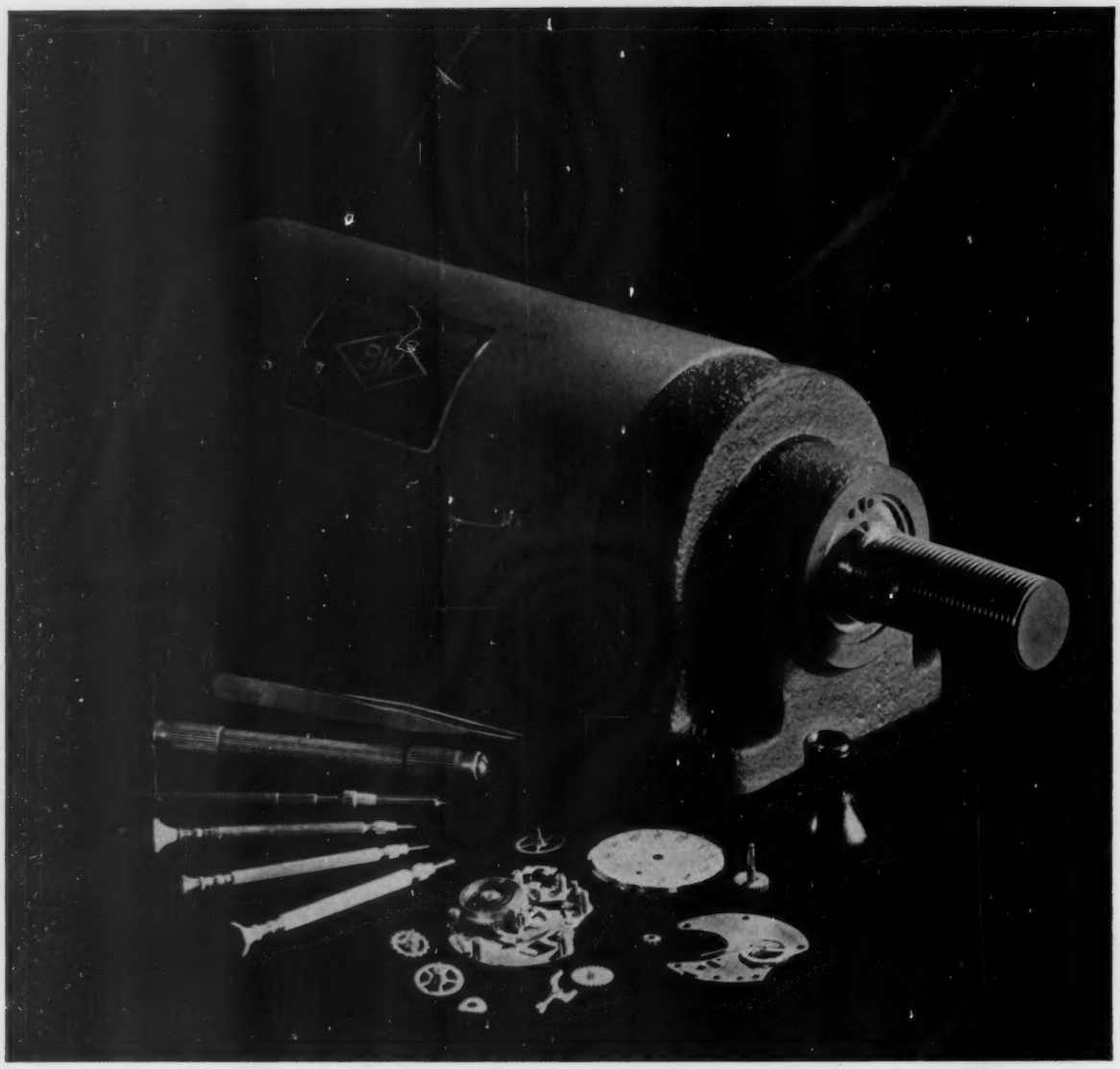
Specify National Acme's SL2X . . . and eliminate limit switching problems under explosive conditions. Tested and certified "explosion-proof" by both Underwriters' Laboratories and the Bureau of Mines, the SL2X is specifically designed for use in the mining, chemical, process industries . . . anywhere explosions cannot be tolerated. Latest of National Acme's dependable SL2 "Machine Life" Limit Switches, the SL2X also offers . . . a variety of cam arrangements for extreme operating flexibility . . . ample overtravel (67°) and by-pass (90°) . . . light operating pressure (12½ lbs. at 1½" radius). Get all the details on this new standard of limit switching dependability and safety. Call, write or wire.

National Acme

THE NATIONAL ACME COMPANY
188 E. 131st STREET
CLEVELAND 8, OHIO

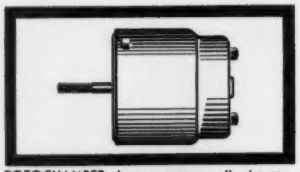
Sales Offices: Newark 2, N.J., Chicago 6, Ill., Detroit 27, Mich.

Circle 441 on Page 19

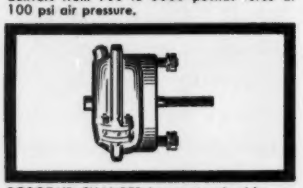


Quality materials and craftsmanship... Bendix-Westinghouse Power Cylinders

You can count on Bendix-Westinghouse for the best in design, materials, and manufacture. Our power cylinder capabilities result from actual experience in every imaginable application—medium, heavy-duty, standard, and special. Our comprehensive inventory of machined parts for standard units, combined with our manufacturing flexibility, means fast delivery to meet your needs. In addition to the broad range of standard models, we can "customize" to your requirements with specialized sizes and mounts. Write today for complete information on the quality advantages you enjoy with Bendix-Westinghouse engineering and manufacturing.



ROTOCHAMBER has neoprene diaphragm, delivers from 900 to 5000 pounds force at 100 psi air pressure.



ROBOTAIR CHAMBER has optional rubber or neoprene diaphragm, delivers from 300 to 3600 pounds force at 100 psi air pressure.

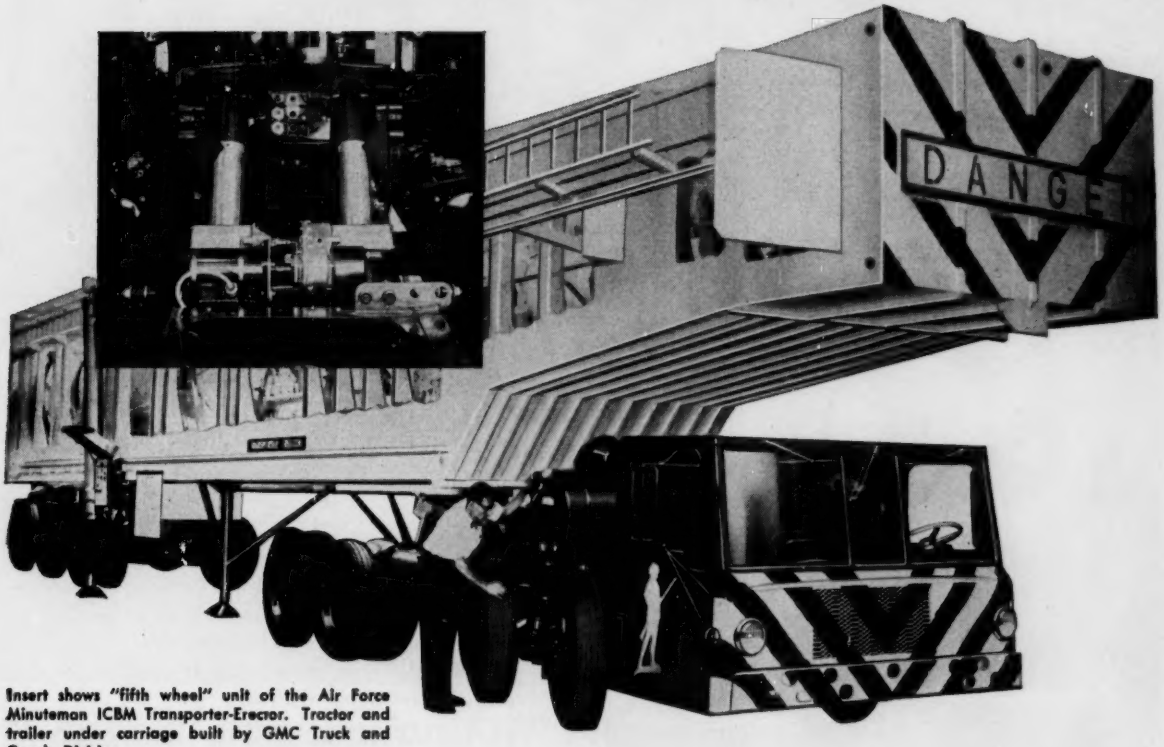
Bendix-Westinghouse BW®

INDUSTRIAL PRODUCTS

Bendix-Westinghouse Automotive Air Brake Company, Elyria, Ohio

Hefting a Heavyweight

...A SNAP with SAGINAW b/b SCREWS

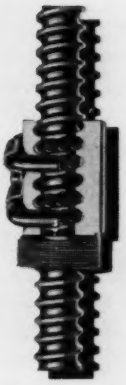


Insert shows "fifth wheel" unit of the Air Force Minuteman ICBM Transporter-Erector. Tractor and trailer under carriage built by GMC Truck and Coach Division.

Low-friction Saginaw Ball Bearing Screws allow a small electric motor in the "fifth wheel" unit to rapidly raise and lower the forward end of this transporter of a 65,000 pound missile . . . allows the transporter to pass under highway overpasses and other low clearance obstacles en-route to underground launching sites.

Also, Saginaw b/b Screws are used for leveling jacks on the rear sides of the carriage unit. The effort required to level the undercarriage is so small the jacks are hand-operated. Each of the jacks has a capacity of 65,000 pounds.

The efficiency of Saginaw Ball Bearing Screws and Splines is being used by designers of today's space, air and ground handling systems. They can lower operating costs, reduce maintenance and simplify designs. And they often reduce installation costs. Whatever your application problem, call on Saginaw to help solve it with Saginaw b/b Screws! Saginaw Steering Gear Division, General Motors Corp., Saginaw, Michigan—world's largest producers of b/b screws and splines.

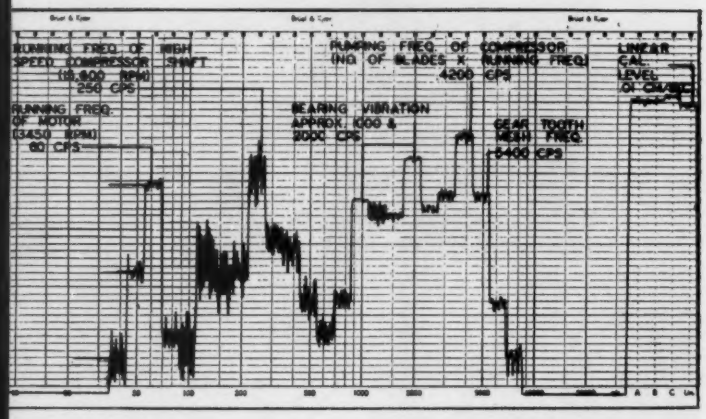


WRITE TODAY FOR NEW 1961 ENGINEERING DATA BOOK OR REFER TO SWEET'S DESIGN FILE

Saginaw ball bearing Screw

Analyze, Identify Source of Product Noise!

Bruel & Kjaer AUDIO FREQUENCY SPECTROMETER and LEVEL RECORDER


RUNNING FREQ. OF HIGH SPEED COMPRESSOR (18,900 RPM) 250 CPS
RUNNING FREQ. OF MOTOR (3450 RPM) 60 CPS
BEARING VIBRATION APPROX. 1000 & 2000 CPS
PUMPING FREQ. OF COMPRESSOR ING OF BLADES X RUNNING FREQ. 4200 CPS
GEAR TOOTH MESH FREQ. 6400 CPS
LINEAR CAL. LEVEL OF CHANGE

The spectrogram shown is a 1/3 octave analysis of the structure borne noise from a large air conditioning unit. The amplitude levels are plotted in true RMS values, an essential to accuracy in such complex signal analysis.

The precise characteristic of the B & K 1/3 octave filters readily distinguishes those frequencies that are the offenders in undesirable noise and vibration.

B & K Model 3312 Spectrum Recorder. Consists of Model 2111 Spectrometer and 2305 Level Recorder.

The B & K Model 3312 Spectrum Recorder is a rapid analysis system very well suited to product evaluation. It earmarks pure tones, beat notes and other noise or vibration characteristics, permitting quick identification and determination of those which must be modified or eliminated.

B & K Model 3312 analyzes complex signal frequencies from 14 c/s to 36,000 c/s and voltages from 5 Micro Volts to 1000 Volts.

Gentlemen:
Please send me
☐ B & K Brochure on Model 3312
☐ B & K Complete Line Catalog

Name_____

Company_____

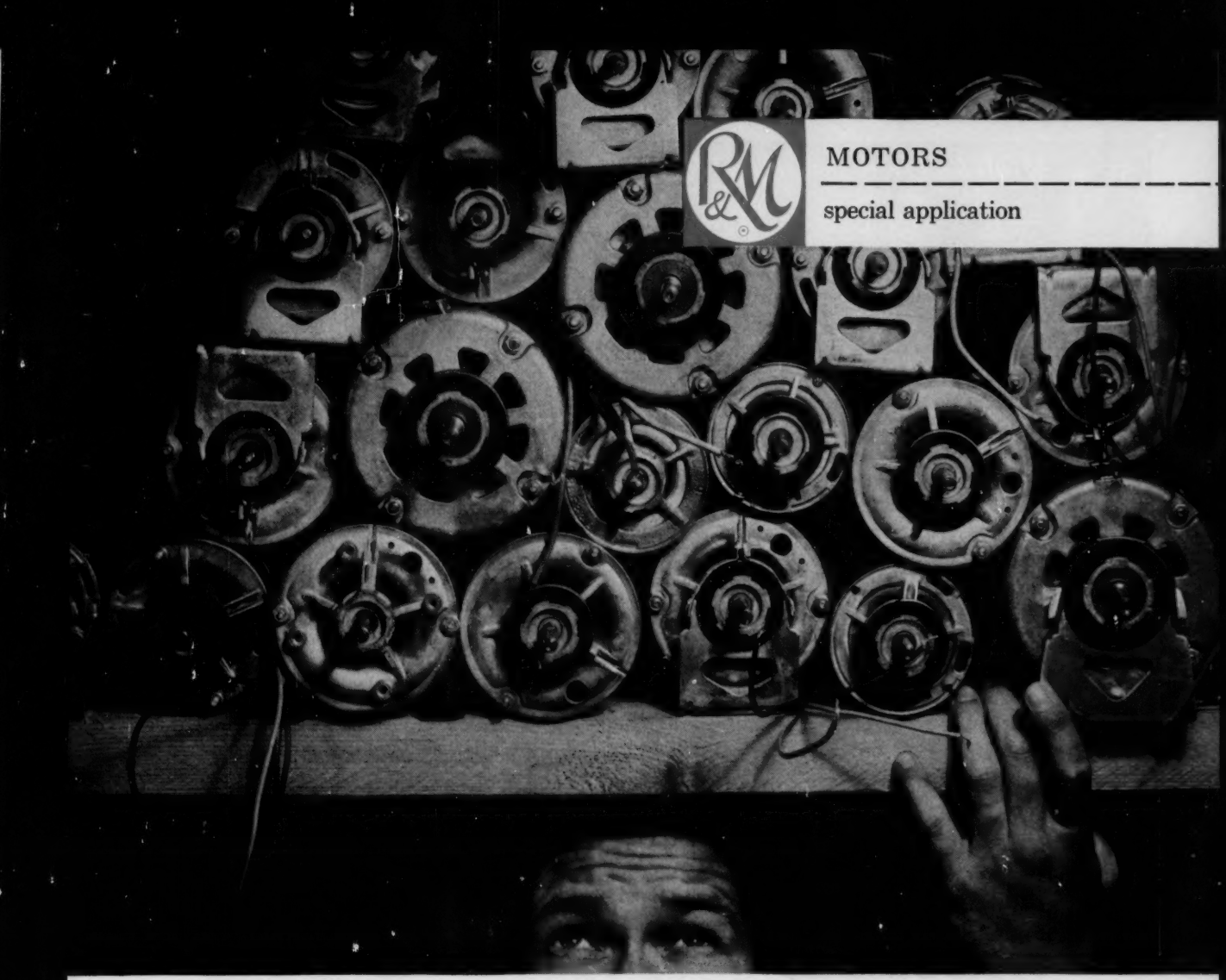
Address_____

City_____ Zone____ State_____

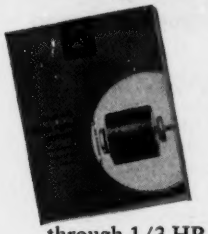
B & K INSTRUMENTS, Inc.

3012 W. 106th STREET • CLEVELAND 11, OHIO • CLearwater 1-8430

Circle 443 on Page 19



if special application FHP motors are on your mind... write for R&M's new Bulletin 445

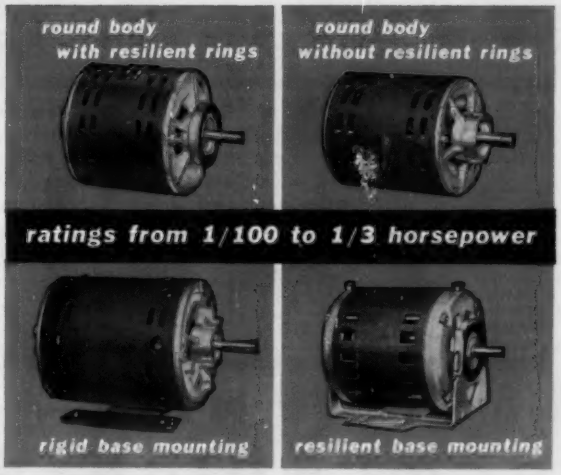


This informative bulletin illustrates and describes in detail Robbins & Myers broad new line of Special Application FHP Motors.

You may select from four frame sizes, sixteen ratings from 1/100 through 1/3 HP, three different pole constructions, three standard mounting arrangements and four electrical types.

Simple, compact and quiet, these motors offer built-in benefits for your customers, as well as design flexibility for you, where silent operation, limited mounting space and minimum attention are factors.

Also, should your requirements be so special that a custom designed motor is indicated, our expert application engineers, using the most modern electronic computers, can promptly select the optimum design for your special requirements. Write today for your copy of R&M's new bulletin 445-MD


round body with resilient rings
round body without resilient rings
ratings from 1/100 to 1/3 horsepower
rigid base mounting
resilient base mounting

ROBBINS & MYERS, INC., Springfield, Ohio

Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

Circle 444 on Page 19

IF A *MINIATURE* OR *INSTRUMENT* BEARING IS NEEDED . . .

NEW HAMPSHIRE

. . . IS THE *SOURCE!*

To meet the exacting requirements of your applications, New Hampshire maintains a full line of miniature and instrument bearings for research and development, prototypes and replacements at all regional offices. (Production quantities are shipped direct from our main plant.) NHBB sales engineers are always on call to discuss your particular needs and make specific recommendations.

Retainer Bearing Plain

Retainer Bearing Flanged

Retainer Bearing Shielded

Retainer Bearing Flanged & Shielded

RETAINER BEARINGS

This is one of the most frequently specified types for instrument applications. Available with newly designed crown retainers. This design permits even ball spacing, low torque, and most consistent performance. *Over 150 standard types and sizes are listed in our Design Manual.*

SIZES

(Available in a wide selection of combinations within the following ranges)

	BORE	O.D.	WIDTH
Min.	.0469	.1562	.0625
Max.	.3125	.6250	.1960

EXTENDED INNER RINGS . . . available on all above types

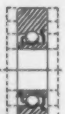
Full bearing (Available plain or flanged)

FULL BEARINGS

Specified for applications requiring maximum radial load capacity. Not suited to low torque requirements. *Over 21 standard types and sizes.*

SIZES

	BORE	O.D.	WIDTH
Min.	.0250	.1000	.0312
Max.	.3125	.5000	.1562



A wafer bearing compared with standard equivalent

UP and WAFER BEARINGS

Expressly designed for use in synchros, servos, small motors, potentiometers, and gear trains. Widths are significantly narrower than standard to allow more room for rotors and stators. *Available in 16 types and sizes.*

SIZES:	BORE	O.D.	WIDTH
Min.	.0550	.1875	.047
Max.	.1875	.4375	.1094

QUALITY PERFORMANCE . . .

is in direct relation to quality of production. *All New Hampshire bearings* are made to ABEC-7 tolerances or better. The result is *improved running qualities* for all users . . . at no extra cost! In addition, rigid quality control during manufacture and continuing research enables New Hampshire to maintain leadership in our field . . . to supply you with the finest bearings for your needs at the lowest cost.

IMMEDIATE DELIVERIES FROM STOCK . . .

(For research & development, prototypes, and replacements) are made from our three regional offices as well as the main plant. Bearing specialists are on hand to help you plan and specify. Call your nearest office collect for fast service.

NEW HAMPSHIRE BALL BEARINGS, INC.

51 Cutter Mill Road
GREAT NECK, NEW YORK
HUnter 2-8633 TWX: 1421U

566 Northwest Highway
DES PLAINES, ILLINOIS
VAnderbilt 7-6646 TWX: 1642U

1540 North Highland Avenue
HOLLYWOOD 28, CALIFORNIA
HOllywood 4-0208 TWX: LA 933U

(main plant)
PETERBOROUGH, NEW HAMPSHIRE
WAlnut 4-3311 TWX: 209U

NEW DESIGN MANUAL

Newly revised and expanded, this authoritative publication is a guide to designing around, specifying and purchasing of miniature and instrument ball bearings. Comprehensive general information, catalog data, and engineering bulletins are included in the 100-plus pages. A personally registered copy is available to qualified engineers, draftsmen, and purchasing departments.

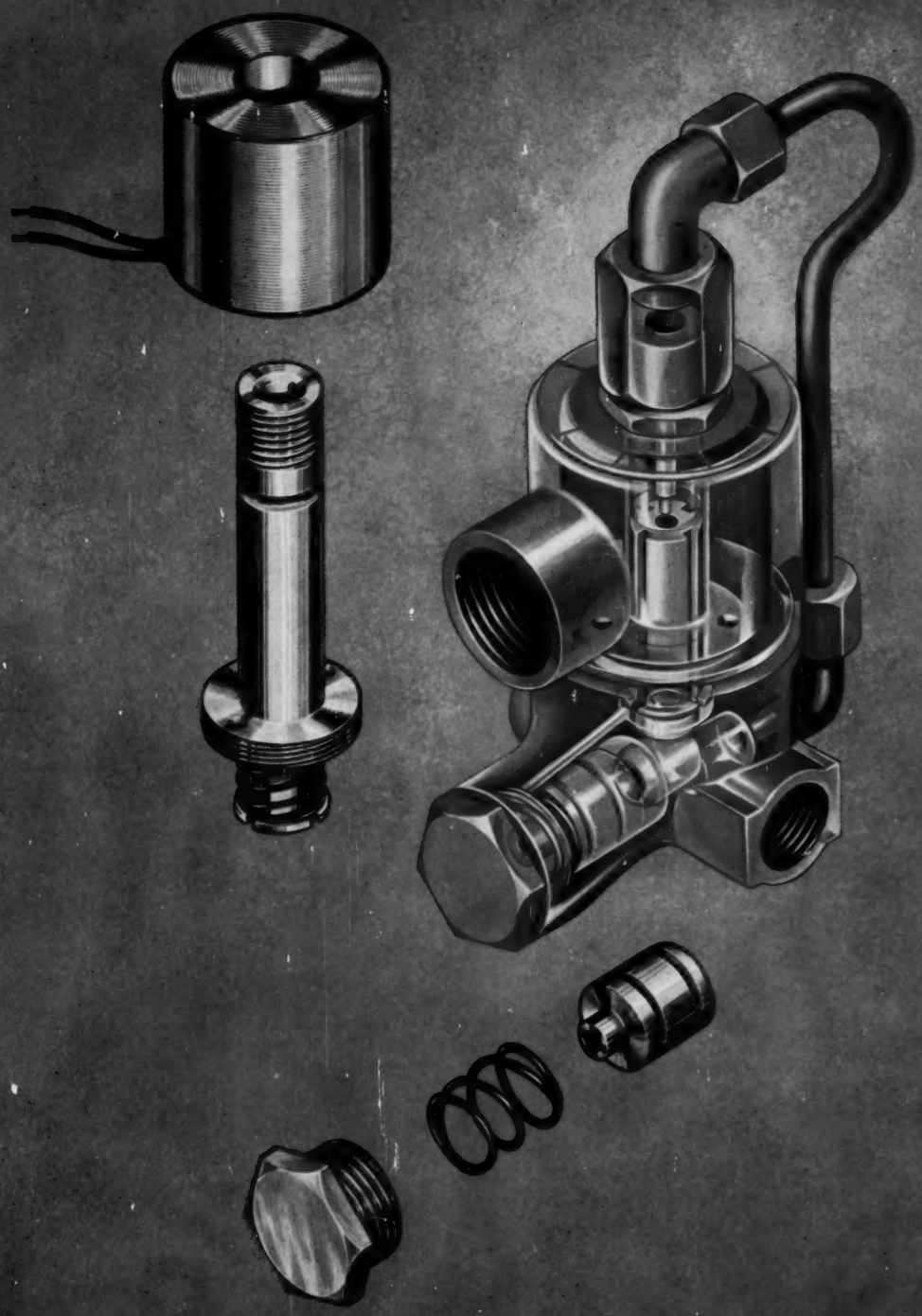
For your free Design and Purchasing Manual, write or call any New Hampshire Office.

NEW HAMPSHIRE BALL BEARINGS, INC.

PETERBOROUGH, N. H.

Circle 445 on Page 19

Circle 431 on Page 19→

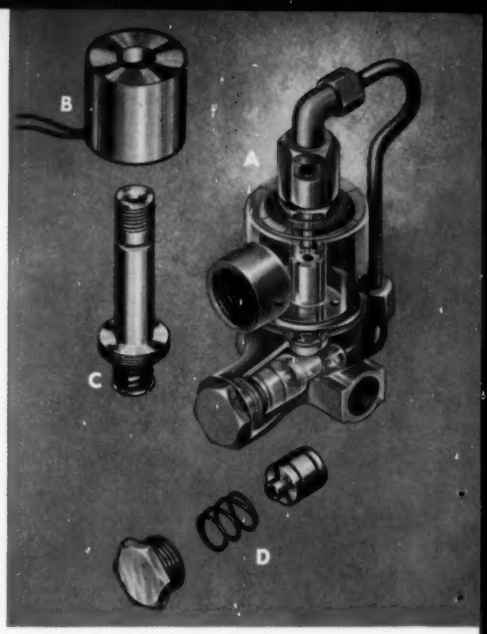


SKINNER 2-way Solenoid Valves

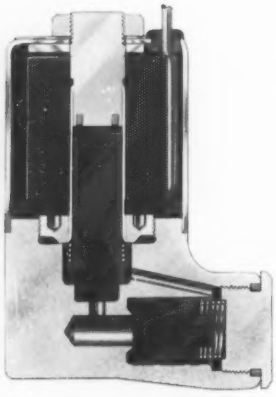
for high flow, high pressure applications

Here's how Skinner two-way valve design provides long lasting, trouble-free operation

- **Underwriters' Laboratories approved**
- **Stainless steel internal parts resist corrosion**
- **Forged naval brass body**
- **Famous Skinner V5 solenoid operator**
- **Well rounded main orifice and pilot seats**



A—Transparent view of normally open 2-way R type valve with piped pilot exhaust return
B—Coil C—Sleeve, plunger and spring assembly
D—Piston assembly with soft synthetic insert



NORMALLY CLOSED TYPE R2

When you have high-flow control problems at standard or high pressures the new Skinner two-way R series valves may be the answer. These pilot-operated solenoid valves are designed for use with air, oil, water, inert gases and other common media at operating pressure differentials of 5 up to 1250 PSI. They may be used for all types of control applications, such as: in high-pressure lifting, commercial laundry equipment, machinery, machine tooling, spraying, etc.

Skinner R series two-way valves have forged naval brass bodies to provide a dense metal structure and use a foolproof stainless steel piston with soft synthetic insert to open and seal the main orifice. Types are available normally open or normally closed, in standard and explosion-proof construction.

To make installation easy for every application, a wide choice of electrical housing options is available. These include JIC, AN connector, automotive terminals, etc. All housings can be rotated 360°. Manual override is also offered to permit manual opening of normally closed valves, or closing of normally open valves, in emergency.

Skinner R series valves may be used with all common voltages and frequencies and there are several coil types such as: varnished, molded waterproof, tropicalized and high temperature for specific applications.

The R series, illustrated here, is just one in a complete range of 2-, 3- and 4-way Skinner solenoid valves.

TWO-WAY R SERIES SPECIFICATIONS

Types	R2 XR2	R2H XR2H	R2H6	RP1 XRP1
Position	Normally closed	Normally closed	Normally closed	Normally open
Pipe Size (NPTF Dry Seal)	¼"	¼"	¼"	¼"
Orifice Size	¼"	¼"	¼"	¼"
Cv Factor	.758	.758	.758	.758
Operating Pressure Differential (PSI) Minimum	5	5	5	5
Maximum AC Service	200	1250	—	150
Maximum DC Service	200	500	1000	150
Leakage	Bubbletight	Bubbletight	Bubbletight	Bubbletight
Temperature Range (Ambient and Media)	Minus 40°F to plus 180°F	Minus 40°F to plus 180°F	Minus 40°F to plus 180°F	Minus 40°F to plus 180°F

When you specify solenoid valves, specify Skinner. Skinner solenoid valves are distributed nationally.

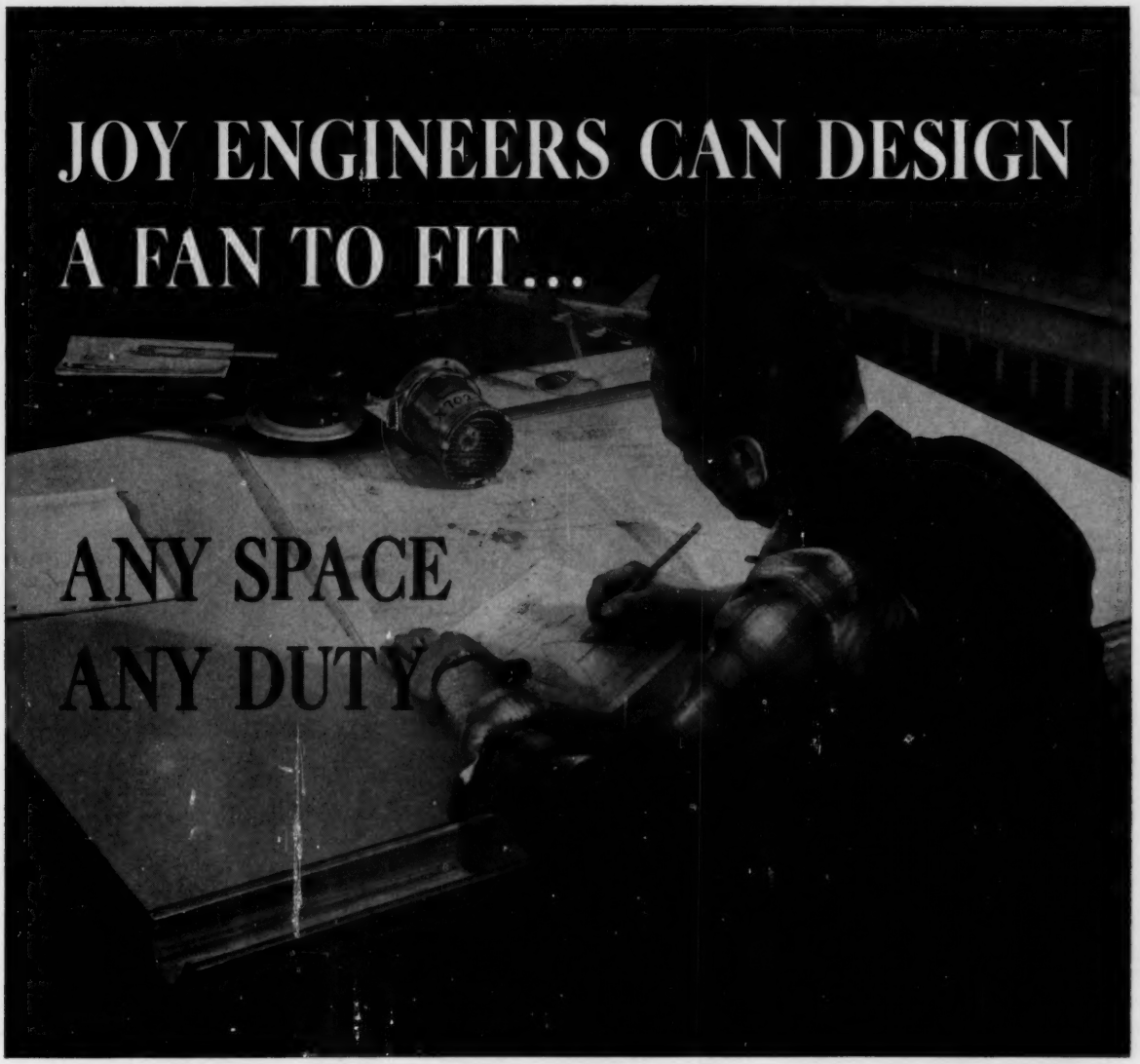
For complete information, contact a Skinner Distributor listed in the Yellow Pages or write us at the address below.

SKINNER ELECTRIC VALVES

THE CREST OF QUALITY

SKINNER ELECTRIC VALVE DIVISION
SKINNER PRECISION INDUSTRIES, INC. • NEW BRITAIN, CONNECTICUT, U.S.A.

PRINTED IN U.S.A.



In many cases the primary requirement for cooling or ventilating fans is that they fit into whatever space remains after the major equipment components have been positioned. Length, width, height, weight . . . any one or all may be critical.

Joy engineers have developed hundreds of fans to meet specific dimensional requirements while delivering air at the required pressure and volume. Performance may be achieved with centrifugal, axial-flow, or mixed-flow designs, providing either fixed duty point or broad operating range performance characteristics. Depending upon application requirements, basic construction may be either cast or sheet metal type fabrication.

Whenever you have an air moving problem, consult your Joy representative. Most requirements can be met economically from the hundreds of stock models available. If a special fan is necessary, Joy will provide an efficient, economical design. For full details on Joy fans, write for Bulletin 2555-64B.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY

JOY

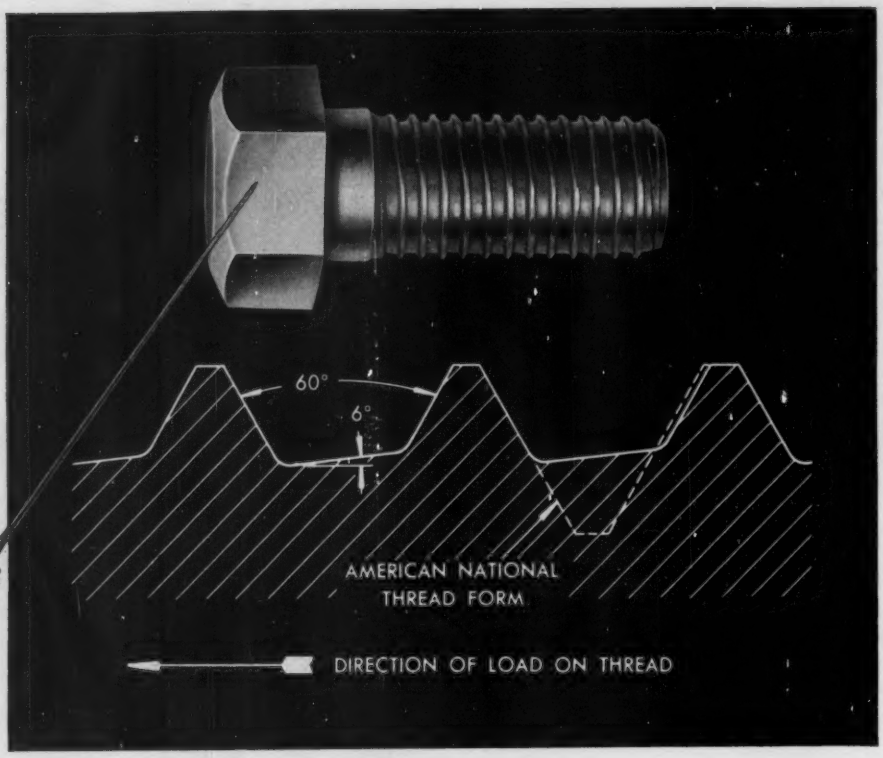
Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

←Circle 431 on Page 19

Circle 446 on Page 19

NAT'S quick facts about Fasteners...



Can **any** fastener actually **become tighter** in service?

WELL, HARDLY. NOT JUST *ANY* FASTENER...

But self-locking, extra-strength LOK-THRED® bolts, studs and screws *do*, and even after long service you can expect their breakaway removal torque to average about 70% higher than at installation.

Here's the reason. Just take a look at the LOK-THRED profile. Notice the extra-wide root? And its converging angle? It's held, strictly by design, to exactly 6 degrees.

Now, see what happens, as you drive any LOK-THRED fastener. It re-forms the metal of the receiving thread, squeezing out every void, and forming an intimate metal-to-metal contact. And each of the angled roots becomes a 6-degree tapered wedge, with the loading constantly pulling against it to make its anchorage even firmer.

That's why LOK-THRED fasteners actually *do* become tighter in service. They're self-sealing, too... fluids can't leak past them. And yet they're fully reusable... require no selective fits... can be used with ordinary tools.

Take our word for it, there are plenty of reasons* why LOK-THRED is superior for many kinds of fastening... and we'll be glad to help you develop any applications to your own products.

*They're all given in National's LOK-THRED booklet, with plenty of supporting data. Write for your copy.

National PRODUCTS

The National Screw & Mfg. Company · Cleveland 4, Ohio

California Division, The National Screw & Mfg. Company • 3423 South Garfield Avenue, Los Angeles 22, California

Victor sealing development news

New Aluminum Precote Process Insures Positive Gasket Performance

Exclusive Victor Aluminum Precote speeds heat transfer . . . provides higher temperature resistance . . . compensates for irregularities of mating surfaces . . . eliminates need of supplementary gasket cement

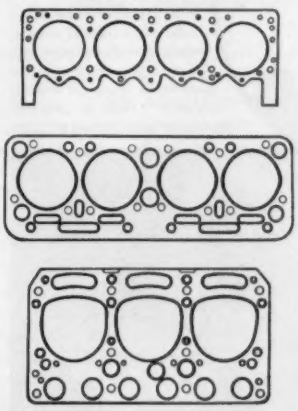
This newly developed Aluminum Precote provides simplified gasket installation and insures positive performance on high-temperature engine applications.

Deficiencies in earlier gaskets of this type have been completely eliminated by a new and thoroughly tested aluminum pigmented organic coating, and by refinement of the application method.

New Advantages

- The new processing method permits application of coating to finished gaskets, ready for shipment when coated, thus eliminating possible handling damage.

Available Gasket Types and Uses



Improved Aluminum Precote is performing successfully on beaded steel, metal-and-asbestos, metal core, and other gaskets suitable for engine head, manifold, transmission, and similar high-temperature, heavy-duty installations.

- Improved coating formula and new application method permit a heavier and completely uniform film on both gasket faces, in controlled thickness from .00075 to .0015 in.

- Controlled baking of coated gaskets at 400 deg. F. gives notably increased resistance to high working temperatures. Precote adhesion to gasket surfaces is improved.

- Resistance to gasket corrosion on contact with antifreeze and coolants is greater—with reduced possibility of blow-by between combustion chamber openings of gaskets.

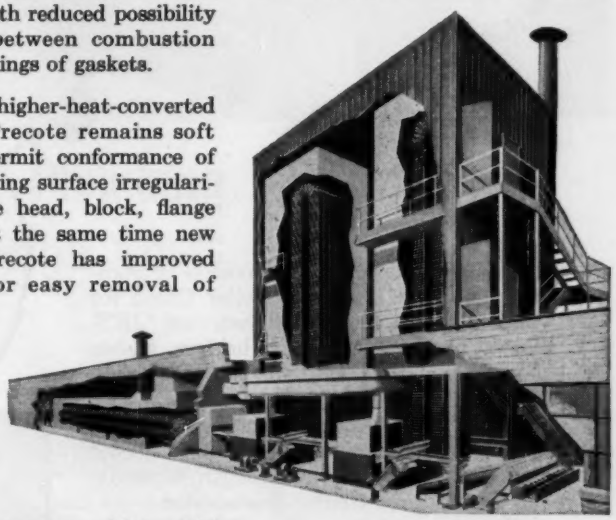
- The new, higher-heat-converted Aluminum Precote remains soft enough to permit conformance of gasket to mating surface irregularities of engine head, block, flange faces, etc. At the same time new Aluminum Precote has improved properties for easy removal of gaskets.

For your test purposes Victor will apply—at no charge—this new Aluminum Precote to two or more pieces on any Victor head gasket you are currently using. This service—or your inquiry for complete technical data and prices—involves no obligation. Handle through your Victor Field Engineer or direct with the factory. See address below.

SAMPLES FREE... ON YOUR OWN GASKETS

New and Improved Facilities Allow High-Capacity Production

Three stories tall, and based on automated conveyor system operation, this Victor installation chemically prepares incoming gaskets, applies and bakes-on Aluminum Precote in one continuous pass. This exclusive system improves the product and gives Victor much-enlarged production capacity.



Victor Mfg. & Gasket Co., P. O. Box 1333, Chicago 90, Ill. Canadian Plant: St. Thomas, Ontario.

VICTOR GASKETS

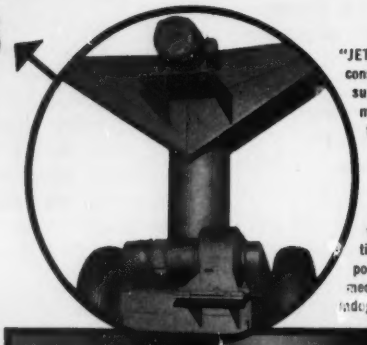
World's leader in gasket design and development for automotive and industrial application

Circle 448 on Page 19

DIAMOND roller chains

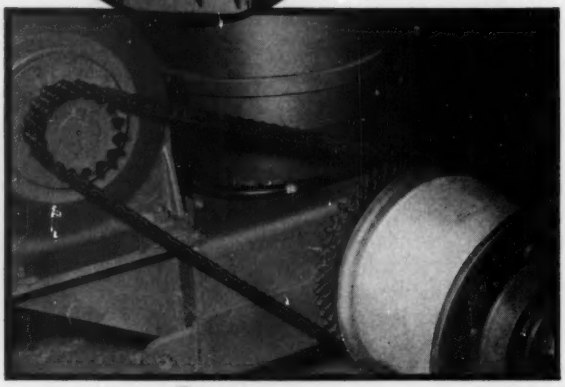
specified for P. I. Steel's elevated

"JETWAYS"



"JETWAY" mechanical drive unit consists of a telescoping column supported by two independent, motor-driven wheels. Three electric motors with DIAMOND roller chain drives are employed in each unit.

Two DIAMOND double-strand roller chains transmit power to wheels (one shown below with tire removed) and one transmits power to the raising and lowering mechanism. Wheels are propelled independently for steering purposes.



P. I. Steel Corporation, Division of Stanray, specified DIAMOND Roller Chain for three drive mechanisms in their new "JETWAY" telescopic loading bridges, shown above in use at United's San Francisco facility.

P. I. Steel, like most leading manufacturers of chain-driven equipment, selected DIAMOND for its proven strength, dependability and long, trouble-free service.

To solve problems of load, shock and fatigue; to insure reliable, low-cost power transfer . . . specify DIAMOND whenever you use roller chain.

Write for the new DIAMOND Roller Chain and Sprocket Catalog No. 760. Engineering service is available from the factory or through Distributors in all principal cities.

DIAMOND CHAIN COMPANY, INC.

A Subsidiary of American Steel Foundries

Dept. No. 435 • 402 Kentucky Avenue
Indianapolis 7, Indiana

Look under "Chains" or "Chains, Roller" in the Yellow Pages for your nearest DIAMOND Distributor

DIAMOND ROLLER CHAINS ®

Circle 449 on Page 19

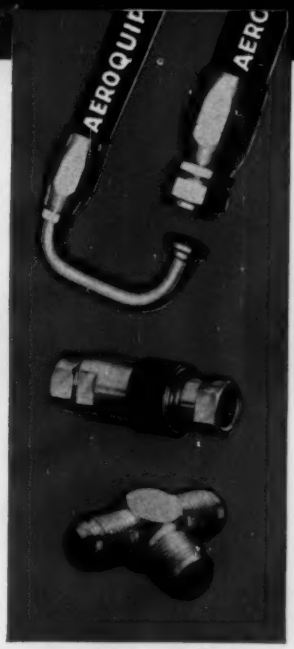
How Aeroquip Prototype Plumbing Service Reduces Your Design Costs

Aeroquip's Fluid Piping Service offers major equipment manufacturers many time-saving and money-saving advantages at the prototype stage. Applying unmatched fluid piping experience, highly skilled Aeroquip specialists can assist your engineers in checking flow and pressure characteristics, installation, routing, and support clamping on fluid piping. Expert recommendations can help eliminate potential problems which might arise later, requiring costly modification.

Backed by the most complete line of fluid piping products, Aeroquip's experienced engineering team can also provide assistance in design, production, service parts and after-sales service in the field. This unique start-to-finish fluid piping service helps assure maximum performance, long life, greater owner satisfaction and reduced field service complaints.

For complete details, call your nearby Aeroquip sales engineer, or write to us.

Aeroquip fluid piping specialists can work with you in every phase of manufacture to assure maximum performance of fluid piping systems on your products.



Aeroquip now produces a wide range of fluid piping products, including hose assemblies with standard or special tube configuration fittings, Self-Sealing Couplings and a new line of tube fittings.

Aeroquip
REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO • WESTERN DIVISION, BURBANK, CALIFORNIA
AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO
AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

Circle 450 on Page 19

Outstanding Performance...

CINCINNATI

CUSTOM GEARS AND GEAR BOXES are *outstanding performers* — the result of old-fashion craftsmanship applied to latest techniques and machines for gear making and inspection.

Ask for this brochure—CINCINNATI custom gears are made in all types to 72″ diameter cut teeth, 39″ shaved teeth, 25″ ground teeth.

better still . . . Send us your prints for quotation

CINTI®

THE CINCINNATI GEAR CO.

Cincinnati 27, Ohio

Custom Gear Makers Since 1907 GEARS, good gears only

The new LICON® line . . . precision switches for every need

In the new, broadened Licon line you'll find every switch designed to meet modern high capacity, long life requirements. These are switches built to do today's tough jobs. Typical is the unique Type 16—heart of many Licon switch assemblies—tiny in size but rugged enough to handle big switch loads with unbelievable life. Check the unusual "specs" of the Type 16, and all Licon types, against your switch needs—see and compare Licon life against any switch—we're sure you'll specify Licon.

Send for catalog on new broad **Licon** *line*

—Gives handy dimensional data and engineering specifications you'll want to keep for ready reference.

Type 30 Enclosed Limit Switches—Interchangeable components form up to 16 switch types for quick replacement. High quality, compact, low-priced. 15A., 125V a-c—for industrial applications.

H—Hermetically sealed Switches—Designed for dependability in extreme environments. Unique, true hermetic sealing against dust, moisture and other elements. Designed especially to your application.

Type 14 Heavy-duty Switch—Built for heavy industrial and machine tool service. Rugged snap-action has large contacts rated 30 amps at 250V a-c.

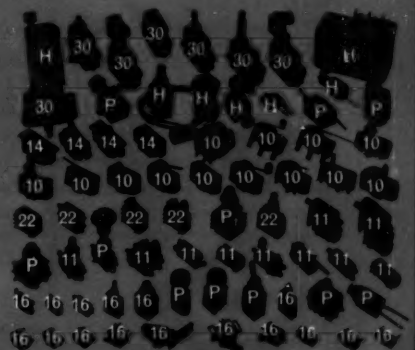
Type 10 Long-life Basic Switch—New Serpentine action mechanism delivers 10 million operations without failure. Can be provided with movement differentials as low as .0005". Rated 15 amps.

Type 22 Double-pole, Double-throw Switches—Provide positive control of four independent circuits. Simplifies controls for multiple circuit applications—withstands 25G at 2000 cps. Rated 15 amps., 125/250 V a-c, 30V d-c (res.).

P—Panel mounted Switches—Variety of types—to 8 or more poles—some solenoid reset or magnetically held—sealed and unsealed as required.

Type 11 Snap-action Switches—Resist 50G vibration to 2000 cps. Double-break, snap-action design eliminates dead break, contact welding and provides greater capacity. Rated 10 amps., 125/250V a-c, 30V d-c.

Type 16 Subminiature Switches—Here's big-switch performance in a tiny unit. Only ¼" thick, 25/32" long—yet rated 10 amps, 30V d-c ind. Greatest shock- and vibration-resistance of any switch in its class on the market . . . even near trip point.



Licon

Circle 452 on Page 19

Available through your local Licon distributor.

DIVISION OF ILLINOIS TOOL WORKS

6608 W. Dakin Street, Chicago 34, Illinois

itw

Designers think of R/M first for asbestos, rubber,

Poly-V "J" Light Duty Drive Gives You Design Advantages Never Before Possible

Most Revolutionary Drive for Small Sheaves, Short Centers, Compact Units

R/M POLY-V® "J" DRIVE is industry's newest and most revolutionary light-duty drive for small diameter sheaves, short centers and compact units. It utilizes a single parallel V-ribbed belt running on space-saving sheaves grooved to mate precisely with the belt ribs. Design advantages of Poly-V "J" add up to more dependable power in less drive space wherever balance and highly efficient, silent, vibration-free drive performance are required.

Advantages

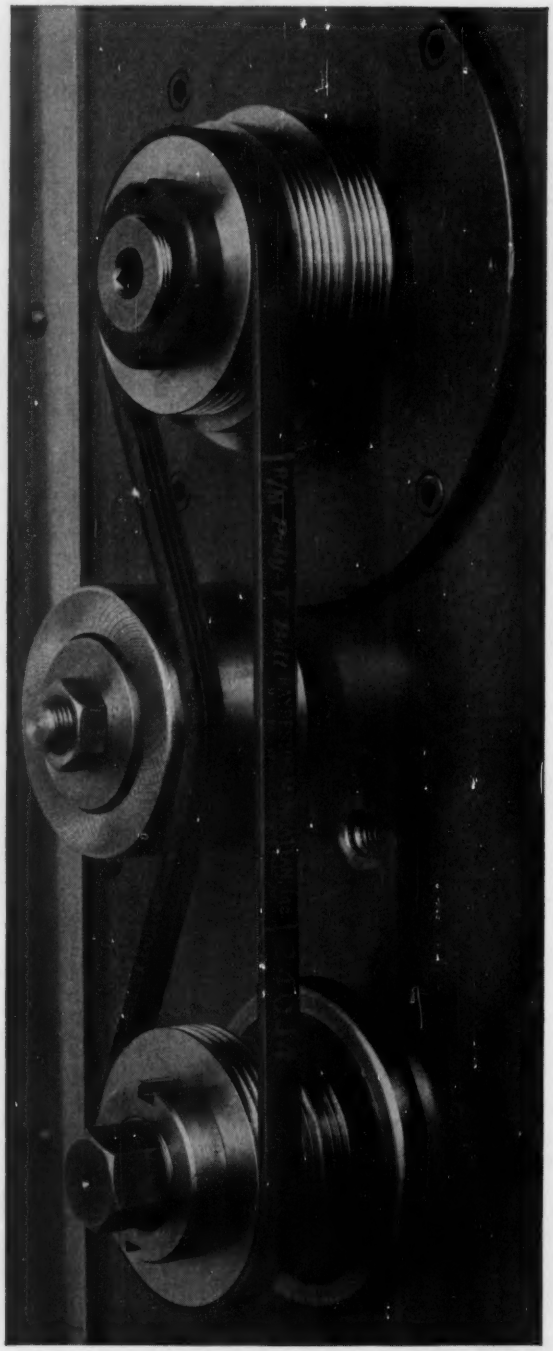
- **Designed especially for small sheaves; considerably below V-belt range**
- **Silent, vibrationless, cool operation; homogeneous traction surface is spliceless, lapless**
- **No belt matching; a single belt cross section meets every need from 1/40 to 15 HP**
- **Delivers much more load in less space; permits more compact drive with smaller mounting clearances**
- **Exceptional flexibility; operates easily with midget motors**
- **Ideal for tandem, mule, ¼ turn or serpentine drives; with reverse bend idlers and for speeds up to 10,000 f.p.m.**
- **Minimum drive wear; assures longer belt and sheave life**
- **Absorbs shock; overload slip protection against machine damage**
- **Complete contact pressure; maintains groove shape**
- **Heat and Oil Resistant**

Poly-V "J" has been proved for smooth, silent power service on a wide range of small machinery—home workshop, machine tools, wash machines, lawn mowers, household appliances, and for many types of industrial, commercial and scientific machines.

For medium and heavy duty drives, R/M Poly-V® is available in the larger "L" and "M" Sections. These 3 Poly-V Belts (J, L and M) will replace 8 V-belt size sections and cover a power range from 1/40 to 1700 HP. Wherever your design problems involve power transmission drives, V-belts, flat belts . . . rely on R/M products and engineering.

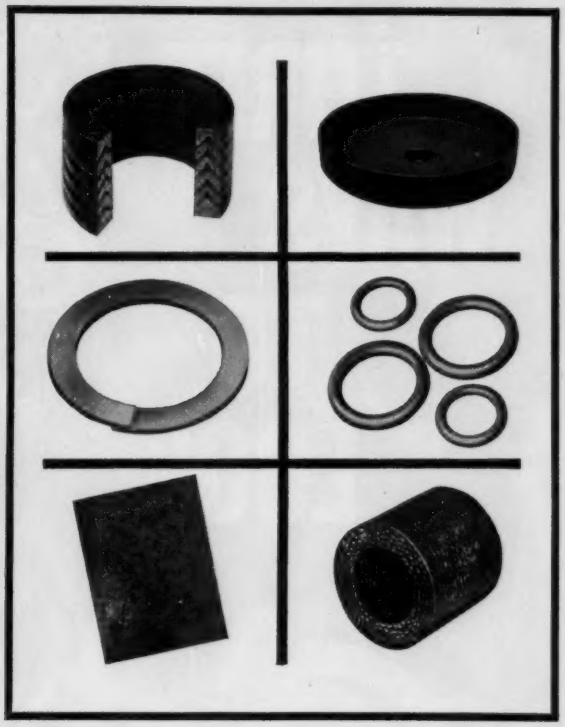
RUBBER

Write today for free booklet shown: full details on a wide variety of industrial rubber products. Manhattan Rubber Division, Raybestos-Manhattan, Inc., Passaic, N.J.



Poly-V "J" on Parker Majestic Grinder as standard equipment

sintered metal, and engineered plastic products



TEFLON* HEADQUARTERS U.S.A.

SHEETS • RODS • TUBES • TAPES
HOSE • BONDABLE TEFLON
MACHINED PARTS • SPECIALTIES

One call does it all. Ask the man from R/M for *anything* you need in "Teflon"—standard shapes to finished parts. He can satisfy your requirements fast and efficiently.

By any measurement—research, complete line, experience, technical data, capacity, quality control, delivery and reputation—R/M should be your *first source* for "Teflon" products.

R/M "Teflon" Headquarters has grown to its present stature through the outstanding dependability of its *own* production and delivery as well as the performance of its finished products.

Contact your nearest R/M district office . . . or write for the application service that cuts costs without cutting corners.

**Registered trademark for Du Pont fluorocarbon resins*

PLASTICS

For a copy of this booklet, full of information on R/M's complete line of "Teflon" products, write Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

R/M CAPABILITY PRODUCES REINFORCED TEFLON PACKINGS

to lower friction, eliminate contaminating lubricants, resist corrosion and extrusion

Now you can get "Teflon" packings with the exact mechanical properties you require. R/M capability has developed a host of reinforced Teflon packings, one or more of which may meet your requirements.

Among these are Vee-Flex® rings, piston cups, gasket materials, and specially machined and molded products. Each is designed for a specific application—using the advantages of Teflon coupled with the advantages of other materials.

R/M's broad experience in design, compounding and manufacturing of mechanical packings and gasket materials is at your disposal. Send data on your specific application.

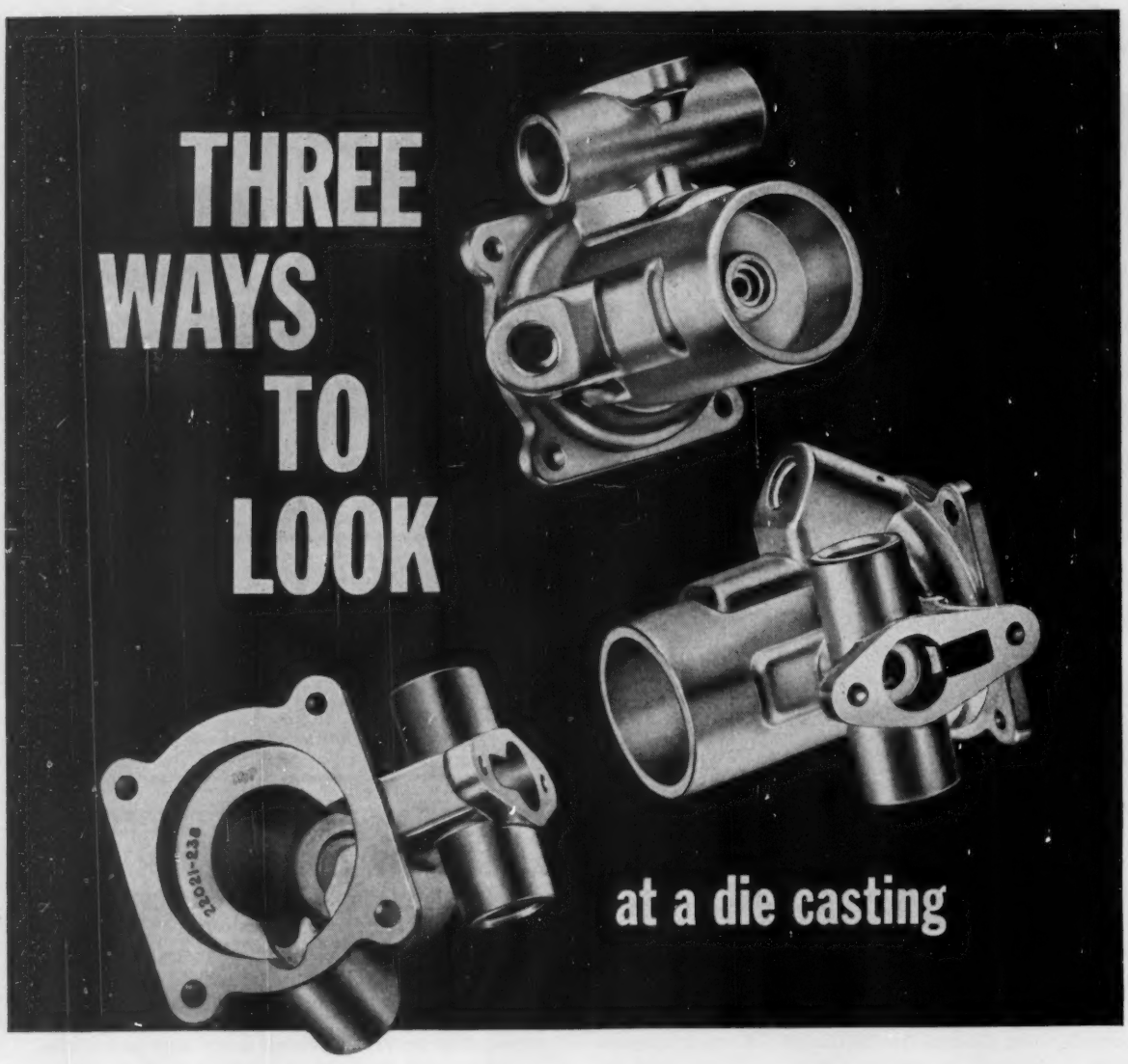
PACKINGS

Write for new catalog giving complete information about Reinforced Teflon Products and other R/M packing and gasket materials.

RM 110

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • Fullerton, Calif. • No. Charleston, S.C.
Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada



Madison-Kipp zinc and aluminum die castings

Here is a gas valve housing so intricate no one view could do it justice. Notice that the holes which are cast in reduce secondary operations. Cast in seats must be smooth and flat to prevent any danger of leakage. Dimensions must be held to close tolerances.

There are three ways to look at a die casting. First, the engineering that goes into the design and the skilled die making that assures perfect castings. Second, the experience of the die caster that guarantees quality parts in quantity. Third, his reliability and responsibility backed by years of die casting experience.

On all three counts—engineering, production, responsibility—Madison-Kipp has won the confidence of manufacturers who demand the finest.

We have a 24-page book showing some of the die casting problems we have solved, and containing information on other Madison-Kipp products. A copy is yours for the asking. Write for one.

kipp

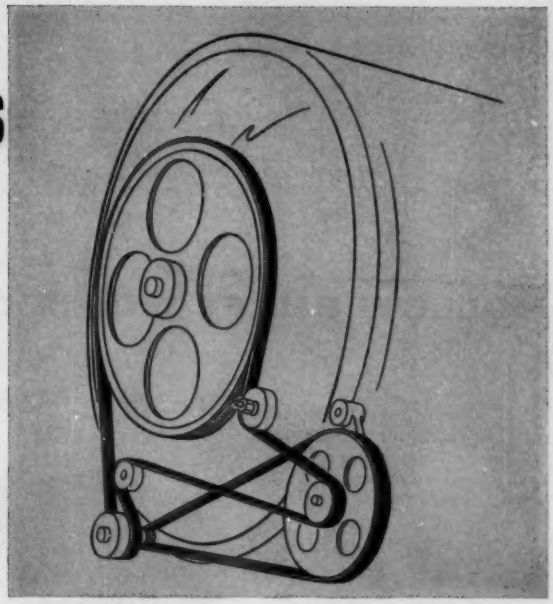
MADISON-KIPP CORPORATION

210 Waubesa Street • Madison 10, Wisconsin, U.S.A.

Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High-Speed Air Tools

Circle 456 on Page 19

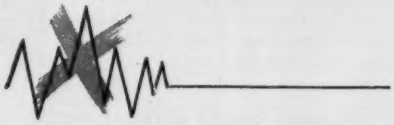
DAYTON POLY-V® Drives pack more power in smaller spaces



Offer engineers greater versatility in drive design

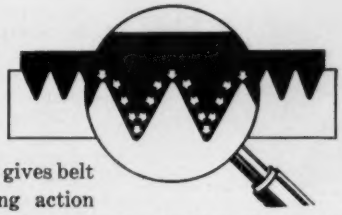
Dayton Poly-V Drives are *single* units. They run in sheaves designed to mate perfectly with belt ribs. This provides twice the tractive surface per inch of sheave width . . . *up to 50% more power in ¾ the space.* Result —a more compact, lighter drive . . . less shaft overhang.

Vibration free



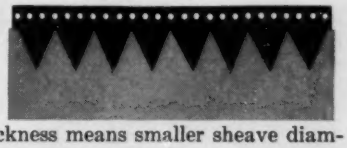
Full contact design guarantees smooth, vibration-free operation. Full molded surface has complete contact with the sheaves. Poly-V belts have uniform belt thickness—no slipping . . . no creeping.

Greater horsepower capacity



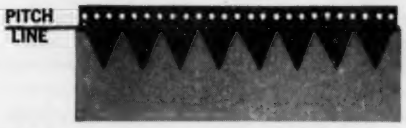
Full contact design gives belt ribs greater gripping action in sheave grooves. Belt tension is transferred equally and in all directions through the belt ribs to the sheave groove walls (hydrostatic principle).

Greater flexibility



Reduced belt thickness means smaller sheave diameters (as small as ¾" with "J" belts)—less centrifugal force. This permits operations at higher belt speeds (up to 10,000 FPM for Poly-V "J")—ideal for high speed motors.

Uniform speed ratios



Full contact design distributes the load equally over the entire contour of the V-ribs. Peak loads cannot cause the Poly-V belt to ride lower in the sheave grooves. Pitch diameters and speed ratios remain constant from no load to full load condition.

Simplified drive design

Only 3 Poly-V cross sections are required:

"J"—from fractional to 10 HP
"L"—for intermediate drives (5 to 50 HP)
"M"—for high HP drives (25 HP and up)

See your Dayton engineer

Let Dayton's Engineering Service help you with your drive design. Call or write:

®Registered trademark of R/M Inc. Manufactured by Dayco Corp. under exclusive license of Raybestos-Manhattan, Inc.

Dayco

©D.C. 1961

INDUSTRIAL DEPARTMENT

Dayton Industrial Products Co.

2001 Janice Ave., Melrose Park, Ill.

Division of Dayco Corporation

Engineering Data

WINSMITH SPEED REDUCERS

HOLLOW SHAFT WORM GEAR SPEED REDUCERS

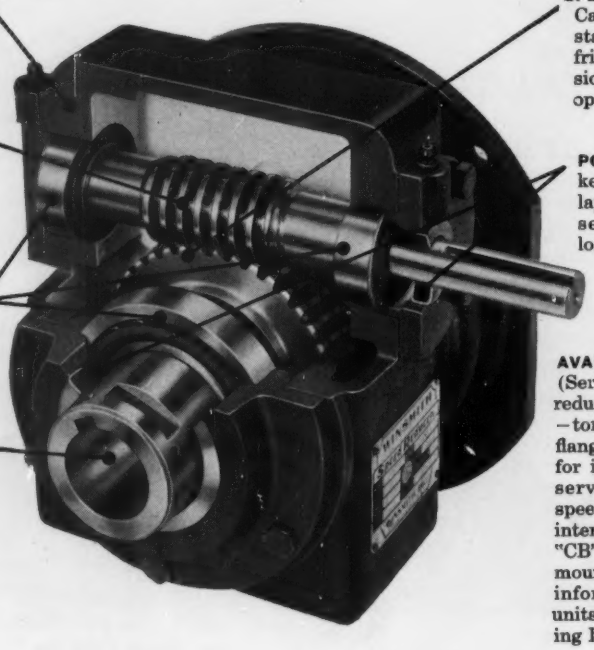
single and double reduction . . . torque arm and flange mounted models

CAST IRON HOUSINGS designed for high heat radiation. One-piece construction, close-grained gray iron for maximum strength and rigidity.

CASE-HARDENED STEEL WORMS cut integral with the shaft. Heat treated for close-grained tough core, carburized and hardened before grinding. Meet AGMA long-wear specifications.

TAPERED ROLLER BEARINGS for minimum maintenance, long bearing life and permanent shaft alignment. High radial and thrust load capacity.

HOLLOW SLOW SPEED SHAFTS in wide range of standard bore sizes and keyways. Mounts on shaft of driven machine *without bushings*—two external slots facilitate removal with standard wheel puller.



SPECIAL BRONZE WORM GEARS Cast to recommended AGMA standards. Low coefficients of friction and thermal expansion for cooler, more efficient operation.

POSITIVE OIL SEALS keep oil in, dirt out. Shafts lapped to micro-finish under seals for uniform contact, longer seal life.

AVAILABLE in single reduction (Series ST and SF) and double reduction (Series STD and SFD)—torque arm ("T" models) and flange mounted ("F" models)—for intermittent or continuous service. Hollow shaft slow speed assembly of "ST" series interchangeable with Winsmith "CB" and "CT" Series with foot mounted housings. For further information on these latter units, write Winsmith Engineering Department.

- *12 Models*
- *.041 to 8.82 H.P.*
- *Ratios 7½:1 to 4466:1*
- *Max. Output Torque 816 to 7678 in. lbs.*

Winsmith Hollow Shaft Speed Reducers cover a broad range of power transmission requirements for both single and double reduction drives. *Their worm gearing provides much higher reduction ratios than are possible in comparable size units using other types of gearing.* Winsmith Hollow Shaft models are designed for all applications where it is advantageous to mount the reducer on the shaft of the driven machine. They are compact, easy to install and require less space than conventional units. Their design and construction provide high shock load resistance; maximum thermal capacity without induced cooling; greater overhung capacity; and a high degree of standardization which eliminates excessive special application engineering.

Write today for complete information or call your nearest Winsmith Representative listed in the Yellow Pages. He is a technically trained expert who is always ready to help you with any speed reducer problem. For both standard and special power transmission applications, you'll find it pays to standardize on Winsmith.

WINSMITH, INC.

202 Eaton Street, Springville, (Erie County), New York

MEMBER OF AGMA

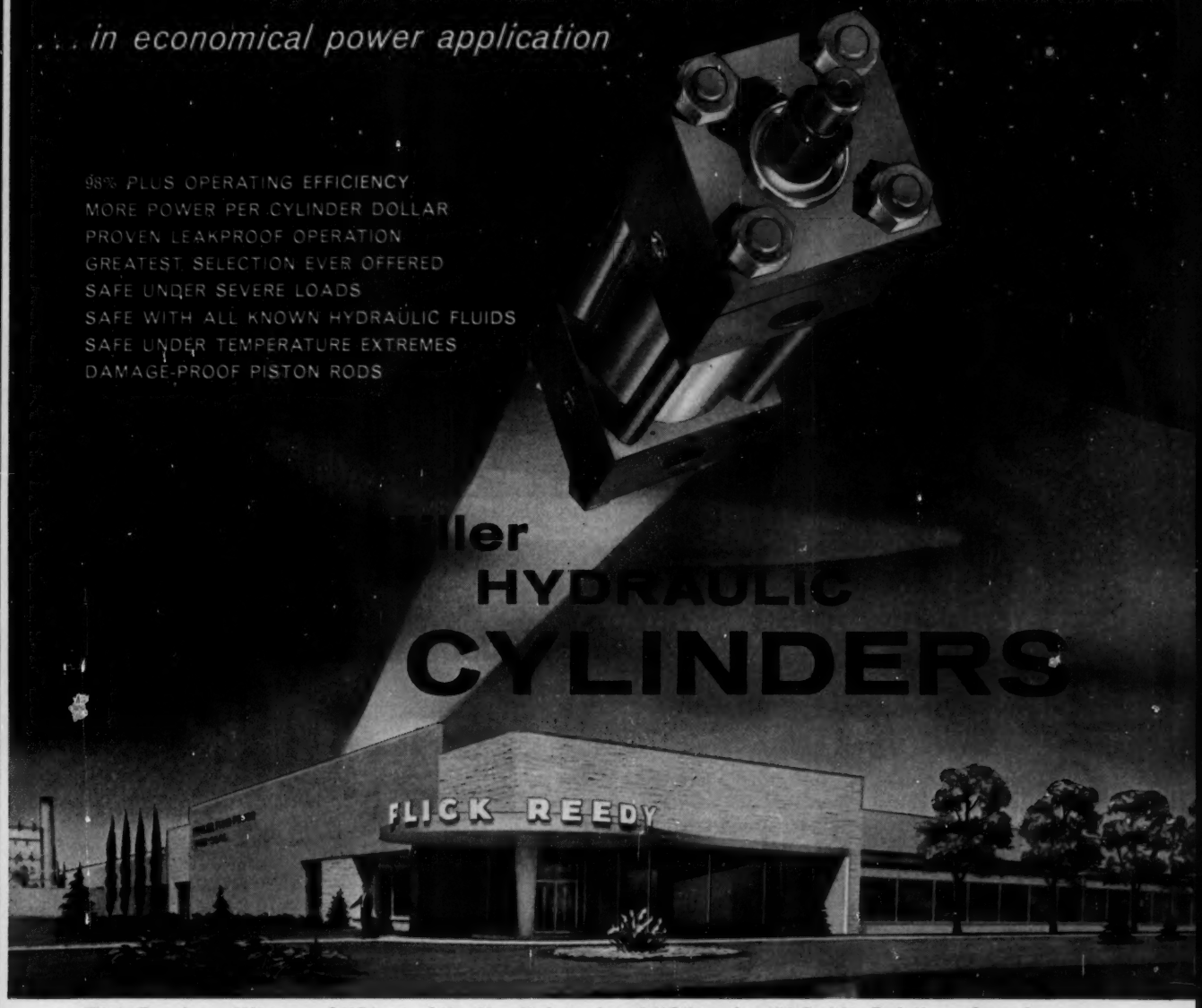
• • • Winsmith Speed Reducers are made by American craftsmen to meet American design and production standards.

Circle 458 on Page 19

OPENING NEW HORIZONS

. . . in economical power application

98% PLUS OPERATING EFFICIENCY
MORE POWER PER CYLINDER DOLLAR
PROVEN LEAKPROOF OPERATION
GREATEST SELECTION EVER OFFERED
SAFE UNDER SEVERE LOADS
SAFE WITH ALL KNOWN HYDRAULIC FLUIDS
SAFE UNDER TEMPERATURE EXTREMES
DAMAGE-PROOF PISTON RODS



Flick-Reedy . . . *Winner of "Plant of the Year" Award and "Silver Anvil" Public Relations Award*

Miller

MORE SAVINGS!

Our ultra-modern, new "Plant of the Year" with its special facilities and operating economies enable us to offer an **extra 10% price savings** on our big "stock" selection of:
Model "H" (Hyd.) Cylinders, 1½" through 8" bores;
Model "J" (Hyd.) Cylinders, 1½" through 14" bores;
Model "A" (Air) Cylinders, 1½" through 14" bores.
Strokes up to 36", cushioned and non-cushioned.

Full Details On Request

Miller Hydraulic Cylinders make impossible applications look easy. With Teflon Seals, Case-Hardened Rods (50-54 Rockwell C), Patented "Shef" Tubing End Seals, and other exclusive *standard* features, these cylinders are practically damage-proof, are ultra-dependable under pressure and temperature extremes, and provide leakproof sealing with ALL hydraulic fluids. Built to *exceed* J. I. C. Specifications, these cylinders are achieving new highs in production and operating economies in thousands of plants. Two great lines: Power-Packed Model H for 3000-5000 psi and Job-Rated Model J for 500-2500 psi. All bores, strokes and mounting styles. Big "Stock" selection for immediate shipment at substantial savings.

Write for literature.

R

MILLER FLUID POWER

DIVISION OF FLICK-REEDY CORPORATION

7N016 YORK ROAD, BENSENVILLE, ILLINOIS

COUNTERBALANCE CYLINDERS - BOOSTERS

Circle 469 on Page 19

REMEMBER COLLAR BUTTONS?

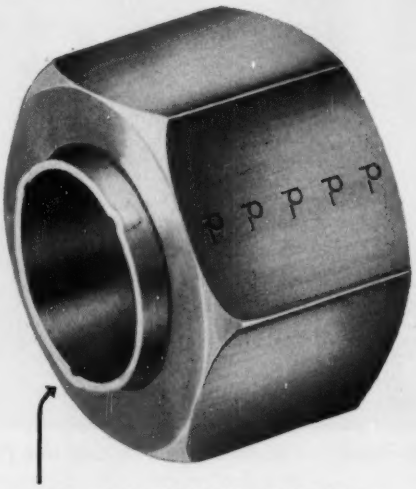
NOW **PARKER** HAS ELIMINATED A MORE SERIOUS ANNOYANCE ...LOST TUBE FITTING FERRULES!

A simple change in the design of Parker "Intru-lok®," the positive, bite-type Parker fitting for copper, aluminum or plastic tubing, has solved an age-old problem.

Small three- and four-piece tube fittings have long been a pain in the neck on applications where it is necessary to remove the nut from the fitting. The ferrule(s) fall out and promptly disappear. If and when found, they often get put in backwards. Sometimes they never get put back at all. Result, in either case: a leaking joint.

Now Parker has developed a snap-in, captive ferrule for "Intru-lok." You can take it out of the nut, "on purpose," but you can't drop it out accidentally.

You get all the leakproof safety of a three-piece fitting with positive "bite." You also get the convenience, the quick, easy assembly of a two-piece fitting. The easiest fitting to install has been made even easier. Write for new "Intru-lok" dimensions and prices today.



Three "detents" hold the "tail" of the new ferrule in the nut. Also, the larger hole in the nut makes tube bends closer to the fitting possible. Note the larger wrench flats on this huskier nut, too.

The new nut with captive ferrule is available on all "Intru-lok" fittings sizes from #2 through #8 (1/16" through 1/2" O.D.). Shown below actual size:

PARKER HANNIFIN CORPORATION

Parker FITTINGS AND HOSE DIVISION

17325 Euclid Avenue • Cleveland 12, Ohio

PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS

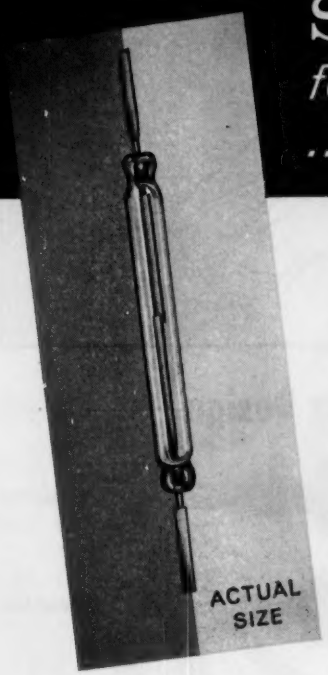
EUROPEAN DIVISION • PARKER-HANNIFIN N.V. • SCHIPHOL • THE NETHERLANDS

8275-PH

Circle 460 on Page 19

Sealed Contact Relays...

for contamination-free operation ...positive on-off switching



CLAREED solves the vexing problem of contact contamination. Its sealed, gold-plated contacts operate indefinitely in an in-built ideal environment, give positive on-off switching for up to millions of cycles. It is a relay you can install and forget.

This maintenance-free operation makes CLAREED sealed contact relays ideal components for such critical applications as transistor drives, computers, data processing equipment and many other high-speed devices.

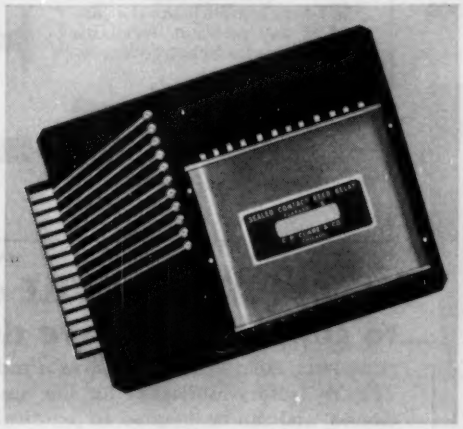
CLAREED design is simplicity itself—a pair of magnetically operated contacts, hermetically sealed in an atmosphere of inert gas within a glass capsule. Compact size permits almost unheard-of flexibility of assembly and application.

See Clareed Relays in working logic modules... No tubes, no transistors.

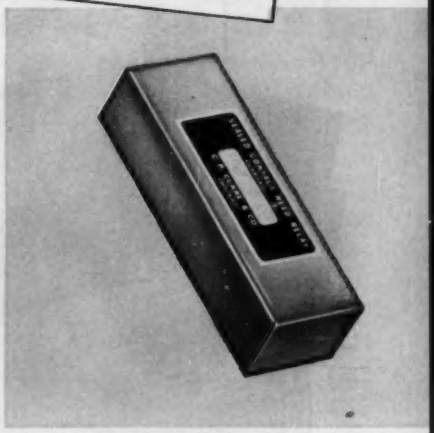
IRE SHOW BOOTHS 2218 & 2220

Typical space-saving Clareed Relay Assemblies

This cylindrical can contains one, two or three CLAREED switch capsules which form the core of a common coil. Numerous variations of this design are possible to meet customer requirements.



CLAREED relay consists of 12 switch capsules enclosed in a rectangular container and mounted on printed circuit board. Varied coils and contact arrangements available.



Here is a CLAREED relay module for printed circuits. Quick, convenient mounting on your own prototypes or assembly line. High component density. Sturdy steel cover provides magnetic shielding.

Circle 461 on Page 19

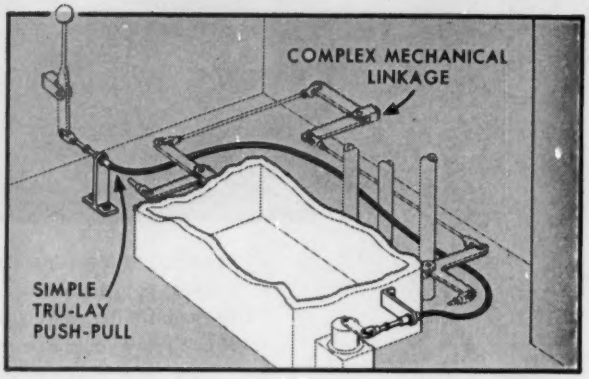
C. P. CLARE & CO.

Relays and Related Control Components

If you use relays, it will pay you to know all about CLAREED relays ...an entirely new concept in relay design. To obtain Bulletin CPC-10, address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Limited, 840 Caledonia Road, Toronto 19, Ontario. Cable Address: CLARELAY.

TRU-LAY *PUSH*-PULL CONTROLS PROVIDE ACCURATE, DEPENDABLE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

• If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over long or short distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



Sizes and Operating Heads to Fit Your Design

Control Dimension	Minimum Recommended Radius in Inches	Maximum Input Load in Pounds (Dependent on Travel)
3/32"	2	30
1/8"	3	65-125
3/16"	5	115-175
1/4"	6	300-600
5/16"	8	700-1,000

Heavy Duty • For use where rugged duty prevails, but where operation must be smooth and accurate. Meets all requirements for dependability and life.

Light Duty • Gives smooth, accurate and dependable performance at low cost. Available with your choice of several types of knobs.

Selective Friction • Amount of friction can be changed to meet individual requirements of the operator or application. Friction constant at any setting.

Position Lock • A slight turn of the T-type handle locks the control in any position. Available in two sizes for light and heavy-duty applications.

Micro Control • Push or pull the knob for instantaneous response, then rotate knob for vernier adjustment. Built for smooth, efficient operation on any job.

PUSH-PULL DATA FILE shows how to simplify, improve design

PUSH-PULL CONTROLS are solid as a rod and flexible as a wire rope. They're factory-lubricated for life, unaffected by temperature extremes, and can be adapted to practically any application. For complete details on how you can use them, write for the PUSH-PULL DATA FILE. It contains 7 engineering Bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages. Our engineers will be glad to help you make TRU-LAY PUSH-PULL CONTROLS a part of your product.

PUSH-PULL CONTROLS

Automotive and Aircraft Division • American Chain & Cable Company, Inc.

601-A Stephenson Bldg., Detroit 2

6800-A East Acco Street, Los Angeles 22 • 929-A Connecticut Ave., Bridgeport 2, Conn.

ACCO

Circle 462 on Page 19

Circle 463 on Page 19→

KEYSTONE WIRE...

long life "backbone" for gasoline hose...

Electric Hose & Rubber Co., Wilmington, Delaware, world's largest hose manufacturer, reinforces their Delmar gasoline pump hose with Keystone Drawn Galvanized MB Spring Wire to prevent kinking and collapse and to resist corrosion. This high quality wire and rayon cord are circularly woven around an inner hose lining . . . automatic horizontal woven hose machines do the job. The outside cover is extruded over the carcass and the final product vulcanized.

Keystone Drawn Galvanized MB Wire with its close diameter tolerance, uniform temper throughout the coil and special zinc coating has been developed to work perfectly in the highly automated machines of Electric Hose & Rubber Co. Regular galvanized wire just won't work.

Just as Keystone Wire Specialists successfully produced this high carbon quality wire that has proved so satisfactory for Electric Hose & Rubber Co., they would like the challenge of developing a wire to improve upon your present wire product. See your Keystone Representative soon; he will be pleased to discuss your wire problems.

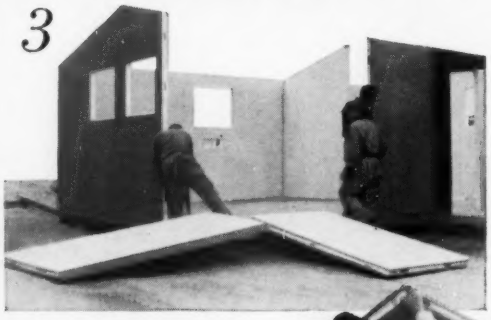
Keystone Steel & Wire Company, Peoria, Illinois

KEYSTONE

WIRE FOR INDUSTRY

MANUFACTURED AT PEORIA, ILLINOIS, U. S. A.

how to build a house in a day...



1 Floor panels are locked to joists laid on permafrost ground.

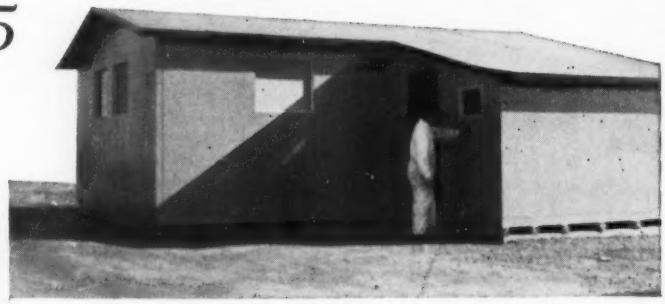
2 Doorway is first wall panel to go up. It locks to floor.

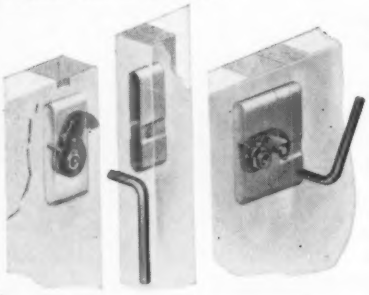
3 Walls and partitions lock to floor and to each other.

4 Roof panels go on last. This takes about three hours.

5 Complete in 7 hours! Floor, walls, roof panels—It's all done with Simmons Dual-Lock fasteners.

Standard Dual-Lock withstands 2500-lb. tension; may be modified for high-load applications to 4500 lbs.





- This house is put up in a day—and can be taken down in half a day!
- Key to quick assembly-disassembly is the Simmons Dual-Lock.

Dual-Lock is a high-load, positive-locking structural fastener perfectly adapted to panel fastening of demountable shelters, shipping containers, covers, cowlings... and to all butt-joint fastening jobs. It can be recess-mounted as in the application pictured, or surface-mounted on sheets or panels. Locks with heavy closing pressure, with very light pressure required on the key.

Arctic Units, Ltd., Toronto, Canada, is putting up 90 "Eskimo Houses" on the DEW Line. Panels, including roof, are plywood-covered styrofoam designed for insulation against Arctic cold.

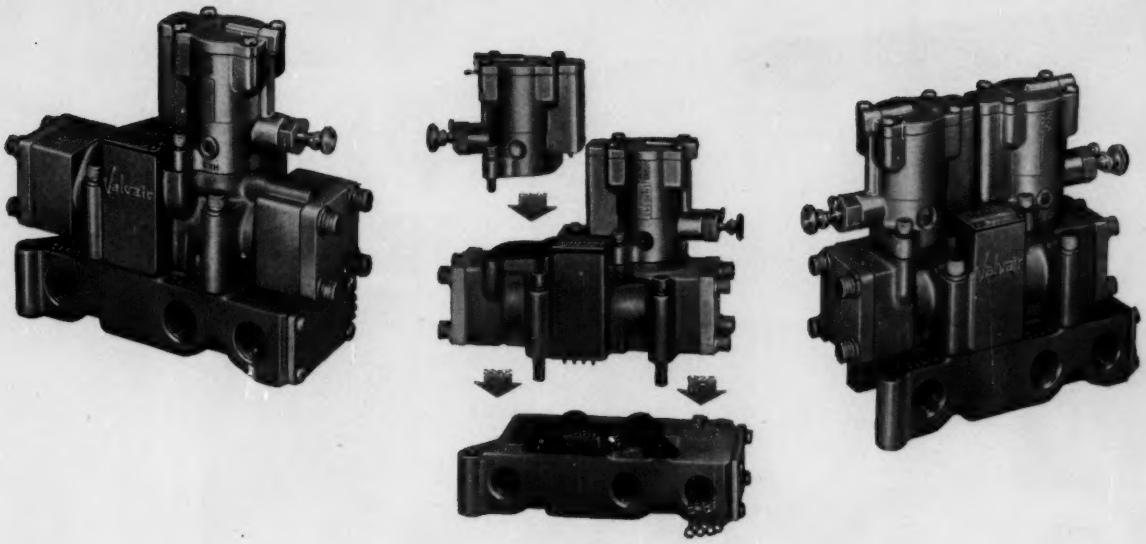
WRITE FOR CATALOG 760. Complete details of Dual-Lock and other dependable quick-operating Simmons Fasteners with unlimited money-saving applications.

- Samples and engineering service available upon request.

SIMMONS FASTENER CORPORATION

1756 North Broadway, Albany 1, New York

LINK-LOCK • HINGE-LOCK • HOOK-LOCK • SPRING-LOCK • CAM-BOLT • DUAL-LOCK • QUICK-LOCK • ROTO-LOCK



4-way single or double pilot-operated types, for sub-base or manifold mounting. Aluminum and stainless steel components assure multi-million cycle dependability. Interchangeable pilots, with coils guaranteed against burn-out for life of valve, fit any plug-in Speed King. Coils for AC or DC, most voltages . . . 35—200 psi range . . . integral junction box . . . optional manual over-ride, sub-base connected external pilot supply . . . ¾ in. separate exhaust ports, ½ or ¾ in. inlet and cylinder ports.

VALVAIR® ½ in. NPT PLUG-IN VALVES

Based on the service-proved design principle of Speed King ¼ in. plug-ins, Valvair's ½-¾ in. plug-in valve series provides plug-in convenience and versatility to a wider range of control valve applications.

Electrical and pneumatic circuits are completed automatically when valve and pilot are plugged in . . . bolted down. The result—cost-cutting reduction of original installation and maintenance time. All power connections are made permanently in sub-base or manifold . . . there's no need to disturb piping or wiring for quick in-service maintenance.

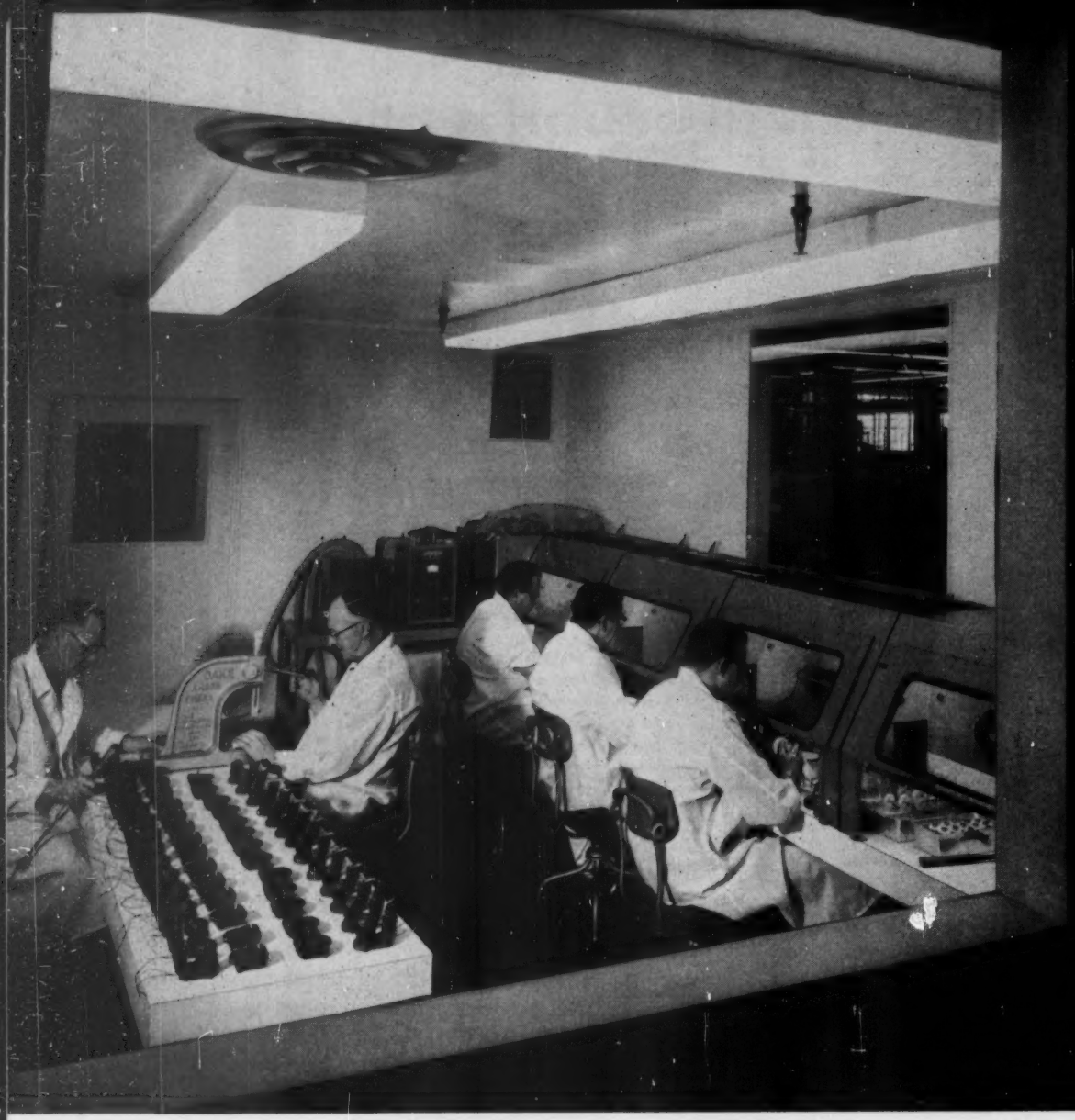
What's more, advanced design shortens stroke . . . speeds response. Separate coded (4-wire) circuits on double solenoid models meet JIC requirements. Flow area through valve and sub-base equals or exceeds that of full ½ in. pipe.

Whether your control valve applications are on the drawing board or now in service, it'll pay you to investigate the advantages of Valvair plug-in design. A call to your nearby Bellows-Valvair field office will bring prompt application engineering recommendations.

For more information, write for Bulletins SPL and DPL. Address Bellows-Valvair, Akron 9, Ohio, Dept. MD-361.

Bellows-Valvair
AKRON 9, OHIO
DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

8170



Lamb Electric's "Clean Room" insures fractional horsepower motor perfection

For assembly of small precision gear motors, Lamb® Electric has installed an air-conditioned, dust-free "Clean Room". This innovation, primarily for the assembly of these custom-built motors, is essential for eliminating even particles of dust.

The "Clean Room" is typical of progressive Lamb thinking that insures perfection in fractional horsepower motor design and manufacture.

Do you have a special motor problem? . . . Here's what you can expect from Lamb! *Into the design* of a Lamb motor goes years of experience in powering components for aircraft, domestic and industrial products. *Out of the design* comes a personalized motor that's dependable, smooth and efficient.

Cost-wise you're way ahead, because Lamb Motors are mass-produced at the most favorable cost.

Write today for descriptive folder. Or ask to have a District Engineer call and set up a personalized "Motor Conference".

THE LAMB ELECTRIC COMPANY · Kent, Ohio

A Division of American Machine and Metals, Inc.
In Canada: Lamb Electric—Division of Sangamo Company, Ltd.
Leaside, Ontario

Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

Divisions of American Machine and Metals, Inc., New York 7, New York TROY LAUNDRY MACHINERY
RIEHLE TESTING MACHINES • DE BOTHEZAT FANS • TOLHURST CENTRIFUGALS • FILTRATION ENGINEERS • FILTRATION FABRICS
NIAGARA FILTERS • UNITED STATES GAUGE • RAHM INSTRUMENTS • LAMB ELECTRIC CO. • HUNTER SPRING CO. • GLASER-STEERS CORP.

Circle 466 on Page 19

Gasket engineering

THE PROPER USE OF SPECIFICATIONS

Specification testing is useful as a method of quality control. But specifications alone do not form a sound basis for gasket selection or predicting gasket performance, since performance is determined by the interaction of many factors.

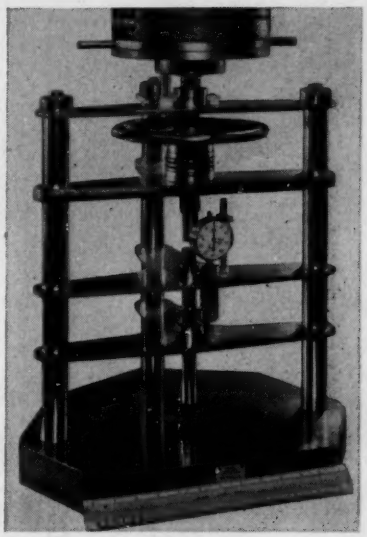
EDISON POWERS
Armstrong Research and Development Center

A resilient gasket material that meets all pertinent government and industry specifications may still fail to provide a satisfactory seal in actual service. At the same time, a material that falls short of one particular specification may well be the most suitable for a certain application.

The reason for this is that gasket performance is determined by many factors—such as flange pressure, contained fluid, qualities of the material—in infinite combinations. It is impossible to set up tests which will take all the combinations of these factors into consideration.

As a result, specifications frequently do not give a realistic idea of the gasket's performance. For instance, many gasket specifications have rigid tensile strength requirements. Tensile strength is easily measured. Yet it usually has little bearing on the sealing ability of a material. For all practical purposes a gasket needs only sufficient tensile strength to hold its shape until it goes to work in the flange.

This Armstrong-developed instrument—called a dilatometer—is used to study dimensional changes in gasket materials caused by different conditions of temperature and humidity. It can detect variations as small as half a mil in a 12" sheet.



This device is used by many laboratories to help standardize gasket testing. Developed by Armstrong and recognized by the National Bureau of Standards, it is used to measure indentation and recovery characteristics of resilient gasketing materials.

Tests for resistance to liquids are also unrealistic where uncompressed strips of gasket materials are completely immersed in various fluids. Test results may show intolerable changes in such factors as volume, compressibility, recovery, and elongation. In practice, however, only the edge of the gasket is exposed, and the effect of the fluid may be negligible.

Other tests—ream weight and bursting strength, for example—have been taken from the paper industry. Again they are of little help to gasket users in selecting materials.

Compounding the difficulties of selection by specification is the lack of standardization in test procedures and instruments. In the matter of compressibility alone, there are the variables of sample size and type of pressure foot, and the method and speed of load application.

Another difficulty with the practice of buying gaskets by specification is the fact that it may delay the discovery and use of new materials that will do the job better. Unless specifications are frequently reviewed, they are likely to be outdated.

Gasketing efficiency can be improved by asking the question, "Will it do the job better?", when you select a material rather than, "Does it meet our specifications?" Once you have selected the proper material, you can establish new specifications and then put specification testing to its proper use—as a means of quality control to make sure that each succeeding shipment of gasket material has the same physical and chemical characteristics.

The Armstrong Gasket Design Manual offers a wealth of research material on gasket design and selection. If you would like help in selecting a gasket material or establishing new specifications or a copy of the manual, write Armstrong Cork Company, Industrial Division, 7103 Dean Street, Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS

your product's reputation and sales... can go down hill fast

...*if nuts keep coming loose*

Suppose you were your own customer, and bought the product *you* make. You'd expect it to stand up to the job, whether it was a racing cart, a heavy-duty crawler, or a crusher. You'd want it to endure the bumps and thumps and constant vibration of rugged use without coming unstuck at the bolts. If a nut came loose and made you lose time or production, you'd certainly think twice about buying that product again.

This is precisely why so many of America's leading manufacturers have guaranteed the reliability of critical bolted connections on their products with Elastic Stop® nuts.

They know that a product's reputation for dependability is built in the field and they know that reorders are written in customers' maintenance records. They've verified through field experience that in the long run Elastic Stop nuts pay their own way because the exclusive nylon locking inserts keep them from working loose . . . even under the most punishing conditions of shock, impact or vibration! Elastic Stop nuts are the equivalent of "free" insurance against fastener failure for *their* product!

Whether your product sells for three dollars or for thousands, we think you'll be interested in a copy of the hex nut catalog No. 706. It details the regular, thin, heavy and light hex types in USS and SAE thread series and various materials and finishes; plus many dimensional "specials".

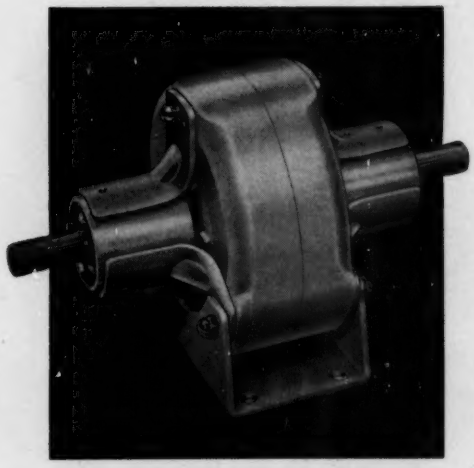
ESNA's complete line may change many of *your* "special" requirements into standard parts. Write Dept. S52-34, Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey.

ESNA®

for the ring ◯ *of reliability*

ELASTIC STOP NUT CORPORATION OF AMERICA

The Vickers Magneclutch® sets new performance standards for delicate torque control



Hair's-breadth accuracy of tension control often determines manufacturing success or failure. As gossamer yarns and ultra-thin paper and foil spin about on high-speed winding reels or bobbins, variations in tension can easily result in breakage, snarling, out of registry, costly down-time.

The Vickers Magneclutch meets this need with precise, delicate tension control—yet possesses a ruggedness that keeps it on the job under the most demanding conditions. Pinpoint control is maintained through the entire torque transmission range, from zero to full speed. Starts and stops, acceleration and deceleration are smooth, without grab or chatter. Available from 11 oz.-in. to 600 lb.-ft.

For complete story, contact the Vickers field engineer in your area, or write for Bulletin Series 6000. EPA 6000-8

VICKERS INCORPORATED
Division of Sperry Rand Corporation
ELECTRIC PRODUCTS DIVISION
1881 LOCUST STREET • SAINT LOUIS 3, MISSOURI

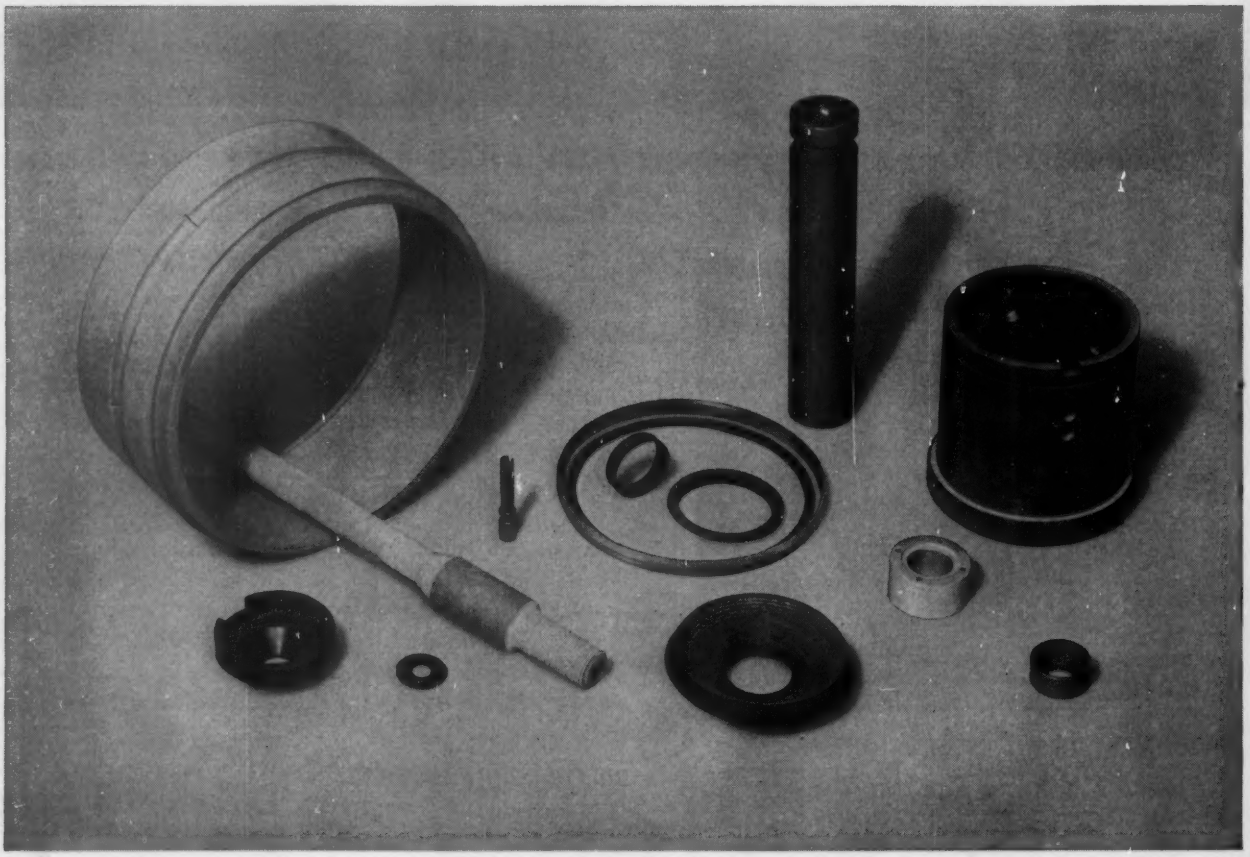
Circle 468 on Page 19

SPECIFYING PARTS FABRICATED FROM INDUSTRIAL LAMINATED PLASTICS?

Taylor Fibre Co. belongs in your specifications

These are just a few of the many parts regularly fabricated by Taylor Fibre Co.

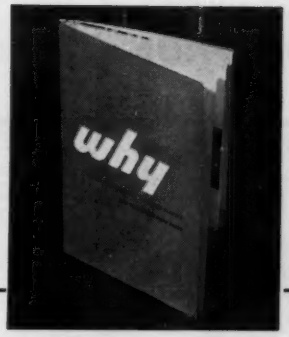
Notice they range from tiny, simple parts to large complex ones. No job is too small or too large for us to handle economically.



The fabrication of accurate parts from laminated plastics and vulcanized fibre requires the right combination of experience, materials, skilled manpower, and equipment to do the job economically—no matter how complex or simple the part may be. We have this combination: **Taylor Fibre Co. is a basic materials manufacturer** . . . produces both laminated plastics and vulcanized fibre in its own plants . . . offers more than 50 different grades of laminated plastics and a number of different grades of vulcanized fibre to fit almost all requirements . . . has been fabricating parts from these materials for many years. **Taylor Fibre Co. has the equipment.** Its Fabricating Division is completely equipped with all machine tools required to produce accurately finished parts to your specifications, even maintains a modern precision toolroom to turn out the dies, jigs and fixtures required, and special tools and machines if necessary. **Taylor Fibre Co. has the manpower.** Toolroom personnel and machine operators are all familiar with the problems involved in the fabrication of laminated plastic parts. And two plants—one in Norristown, Pa., the other in La Verne, Calif.—assure good delivery wherever you may be located.

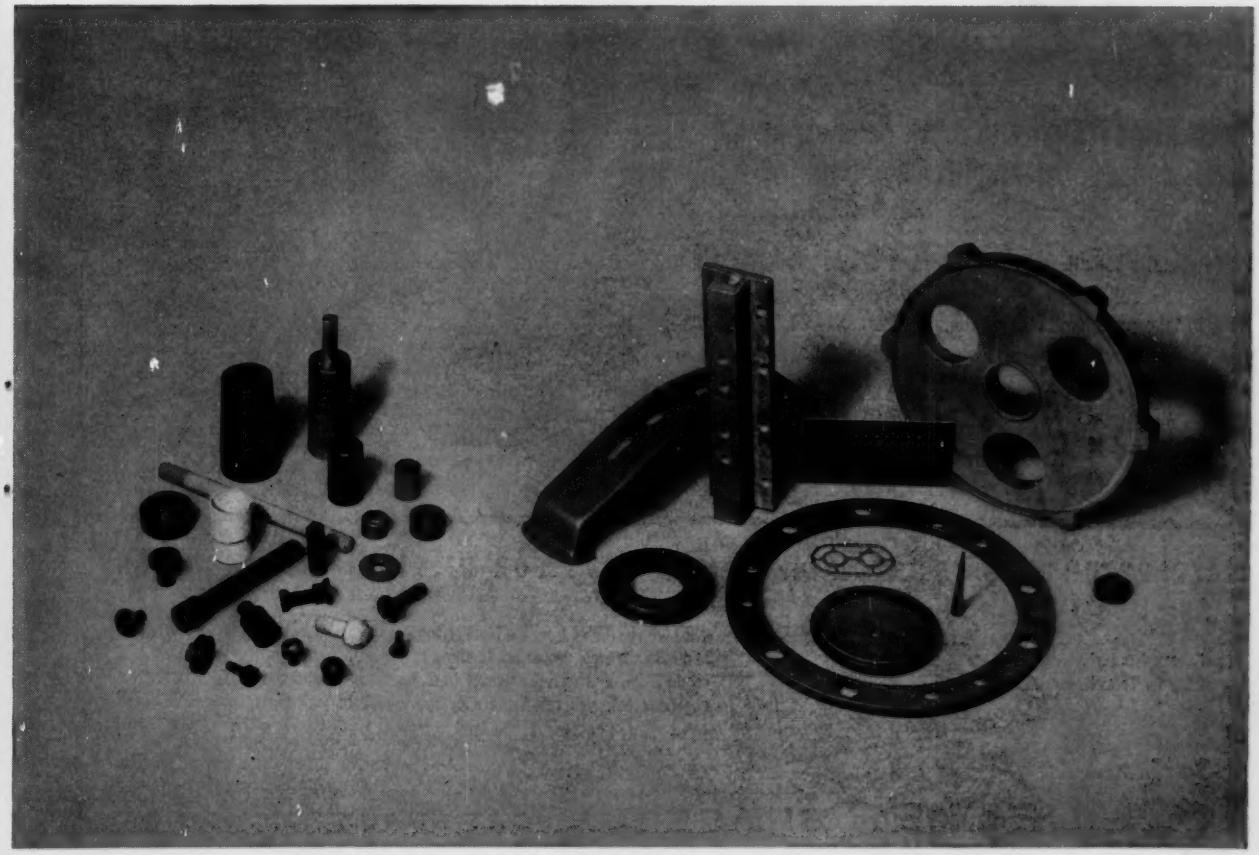
What does this mean to you as a buyer? Simply this. You can reduce inventory investment in raw materials, eliminate production headaches within your own plant, get the advantages of uniform quality control and quantity production, even if you have a number of assembly plants, and also lower unit costs.

Our "why" booklet tells the full story of the experience . . . the manpower . . . and the equipment at Taylor Fibre Co. to fabricate to specifications, in quantities required, in time desired—economically. Write for your copy today. Taylor Fibre Co., Norristown 47, Pa.



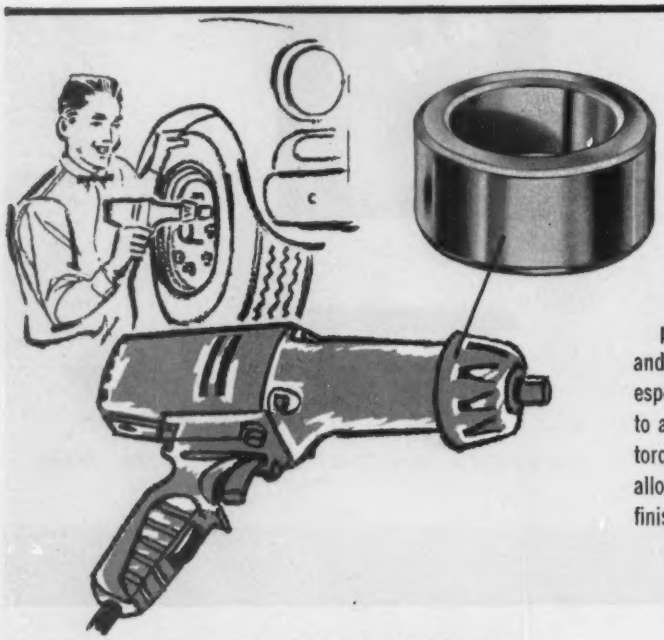
Taylor

LAMINATED PLASTICS VULCANIZED FIBRE



600 SERIES

THE FORGEABLE BEARING ALLOYS THAT STAND UP ON THE REALLY TOUGH JOBS!

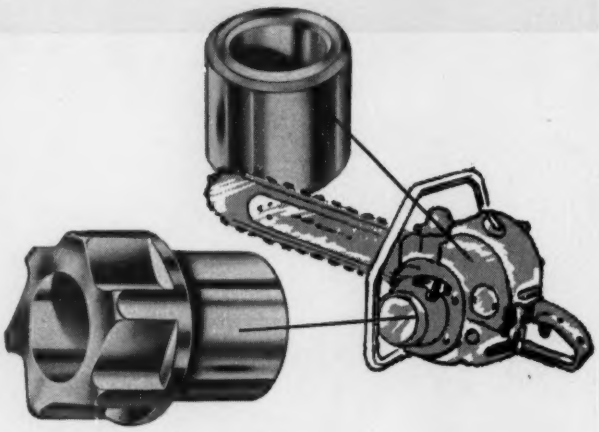


600 ALLOY NOSE BEARING WITHSTANDS THE PUNISHING SHOCK LOADS OF AN IMPACT WRENCH

This heavy-duty impact wrench takes the rigorous punishment of hard industrial use right on the nose . . . and right on the 600 Series nose bearing. This bearing was especially chosen by the manufacturer because of its ability to absorb a range of 1600 to 1800 impacts per minute at a torque of from 0 to 250 foot pounds. By specifying 600 bearing alloy, the manufacturer gets superior performance from his finished product.

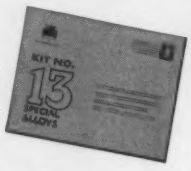
600 ALLOY RATCHET AND DRIVE GEAR BEARING TAKES THE TERRIFIC POUNDING OF A HIGH POWERED CHAIN SAW

Professional woodcutters give chain saws a rough time for hours on end, all year round, and these rugged saws must be built to take punishment. With chain speeds up to 3000 feet per minute, the ratchet and drive gear bearings, for example, must have a very high strength, hardness and good resistance to wear with minimum lubrication. That's why 600 Series Alloy was specified for both parts . . . the ratchet is a forging and the bearing was produced from 600 Series rod.



MUELLER BRASS CO. SPECIALIZES IN ALLOYS FOR DIFFICULT APPLICATIONS

For complete engineering data, write today for Special Alloys Kit No. 13.



The alloys available from the Mueller Brass Co. range from those having high hardness and wear properties, to alloys that must possess excellent electrical conductivity, and ones that must have free-machining properties. Let our engineers help you select the alloy best suited to your exact application.

MUELLER BRASS CO. PORT HURON 20, MICHIGAN

326

HOKE Flow Sheet 4

HOKE REPORTS ON FLUID CONTROL

HOW TO SWITCH PRESSURES IN MID-STREAM

PRESSURE BY THE POUND . . . no matter how thin you slice it!

One trouble with doing something better is that it's hard to stop. This time, we've come up with a new line of pressure regulators. We made them for the technically oriented who have developed high standards and for the penurious purchaser who wants something for (almost) nothing.

One, tagged as the 680 Series, is a highly stable single stage regulator with something for just about everyone. The core of this regulator is its control accuracy of 2% at flows to 2000 SCFH. Two models are available. One delivers 0 to 40 psi and the other 0 to 140 psi and both can handle inlet pressures up to 3000 psi. Use them on any gas compatible with 2024-T4 aluminum alloy, neoprene, polyurethane and Buna-N.

If what we've said sounds good so far, but still won't solve your problems, read on.

We've built a regulator specially for corrosive gases and atmospheres. Available in either all monel or all stainless steel construction, we call it the 640 Series. Spec sheets on this can be had by marking an "X" below.

If you "X" the next box, you'll get a package of useful information on a special regulator that will handle delivery pressures up to 4500 psi with very high control accuracy. This is a 2 stage spring and dome loaded regulator and we claim that a 50% change in inlet pressure will not change the delivery pressure more than 2%. Operation is simplicity itself. For no particular reason, we call this the 920 Series.

Skeptics should send for all of this information.

For reasons now hidden by the veil of tradition, no one has ever attempted to scrunch a pressure switch to its proper proportions—that is, until now. With sales getting bigger from making things smaller, we decided that this was the path to profit. Ergo; the new Hoke Pamar pressure switch.

This isn't just a case of arrested development, but something entirely new. The scrunching process necessitated less parts, so conventional connecting linkages were the first to go. The direct result: a switch with only one moving part—nothing to wear and upset the actuation setting.

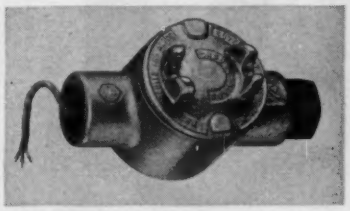
The ordinary bellows was out of the question, so we used a Ni Span C capsular type sensing element. Out of this came such things as high repeatability, minimum hysteresis and drift, maximum temperature stability, and a dead-band of minor significance.

The whole assembly measures less than 2 inches from tip to terminals, and weighs short of one ounce. Despite these diminutive dimensions, it is capable of handling working pressures to 500 psi with a repeatable accuracy of ±0.5%. Electrically, it sports a snap-action switch that will conduct a current of up to 7 amps to a variety of connectors – AN, cabled leads, solder terminals, or whatever you want. Interested in pressure switches for explosive atmospheres? Specify the explosion-proof model.

A special low pressure switch (0 to 7 psi) defies competition with a dead band of 2" of water!

If what you're looking for in a pressure switch seems impossible to find (even with the wonders we've described here), we'd like to hear about it. We thrive on doing what others shrink from, and will build a switch to your specs. Write and tell us your problem.

We could go on, but that wouldn't leave us with the usual advertising "hooker". We want to hear from you. In return, we'll send you the rest of the story.



WHAT'S NEW FROM HOKE?

Lots of things have been happening at Hoke. To be sure you're up to date on these developments in fluid control see your nearest distributor. He'll have something new for you every other month this year.

Hoke's Performance Guarantee—*Every Valve Leak-Tested!*

HOKE INCORPORATED
91 Piermont Road, Cresskill, N. J.

Send me complete information on the Hoke products checked below:

- ☐ Pamar Pressure Switches
- ☐ 680 Series Regulator
- ☐ 640 Series Regulator
- ☐ 920 Series Regulator
- ☐ "What's New"

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

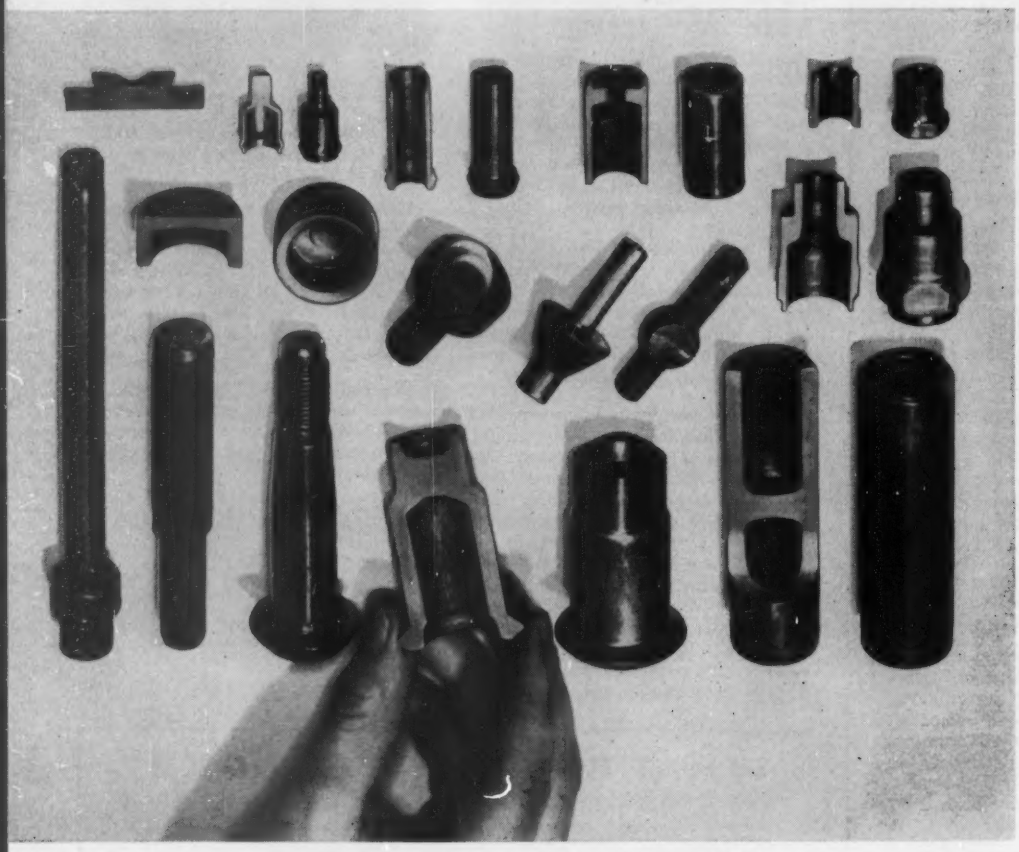
CITY _____ STATE _____

SEE OUR CATALOG IN SWEETS PRODUCT DESIGN FILE

Circle 471 on Page 19

From the industry's most advanced bar mill...

REPUBLIC STEEL FOR COLD EXTRUSION

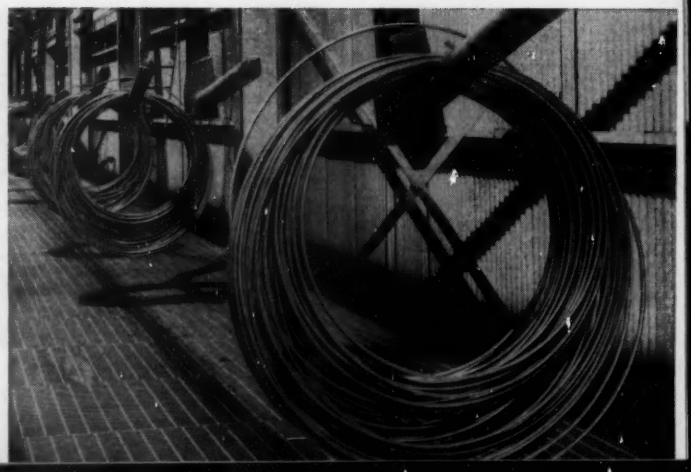


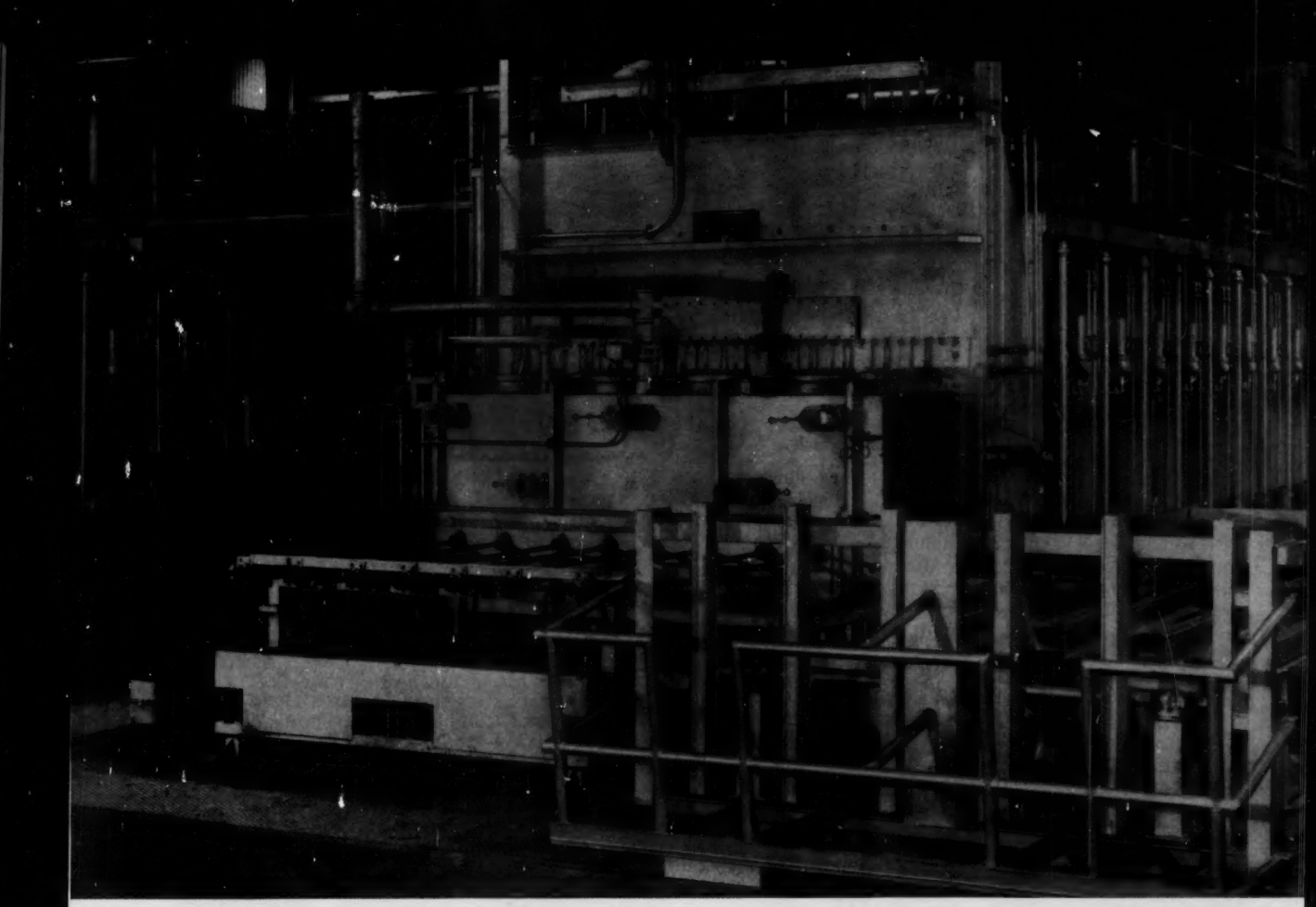
THE COLD EXTRUSION PROCESS virtually eliminates raw material waste. Standard equipment is available so that retooling costs are not excessive. Bars produced on this 11″ mill have denser, more uniform structures because they undergo more hot work. A larger than usual billet—3″ or 4″ square—is rolled to finished products of standard sizes.

Circle 472 on Page 19

HEAVIER COILS weighing up to 1600 pounds mean fewer fabrication changeovers, less scrap loss. High speed coilers handle the complete range of bars produced (⅜″ to 39/64″—700 to 900 pounds; ⅝″ to 1½″—1400 to 1600 pounds). Each coil undergoes ultra-precise inspection to assure conformance to specifications, then is double banded for safe, efficient handling.

Circle 473 on Page 19





Annealed, normalized, or spheroidized to your precise specifications

Atmosphere controlled, continuous annealing furnaces give Republic's new 11″ bar mill maximum annealing capacity. Steel for cold extrusion or cold heading can be furnace-treated, finished, and delivered to your precise specifications. The mill has facilities to pickle, oil, lime, or phosphate coat.

Depending on the nature of your product, you may find it more advantageous to use steel in the cold finished form. Either way, our metallurgists will help you select and apply the most economical bar product—carbon, alloy, or stainless—capable of meeting your requirements.

Republic Steel is the nation's largest producer of steel for cold extrusion. For complete data, contact your nearest Republic representative or mail the coupon below. Please indicate if you would like a metallurgist to call.

Circle 474 on Page 19

Strong, Modern, Dependable

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL

REPUBLIC STEEL CORPORATION
DEPT.MD-1514
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send more information on:

- ☐ Steel for cold extrusion
- ☐ Steel for cold heading
- ☐ Steel for cold forging
- ☐ Have a metallurgist call

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

HANDY ALLOY DATA SHEET

HANDY & HARMAN ENGINEERING DEPARTMENT
82 FULTON STREET, NEW YORK 38, N.Y.

TEC and TEC-Z

...How to choose between a soft solder and a brazing alloy

Handy & Harman provides *two* alloys that fit between "something stronger than the average soft solder but not as strong as a silver-brazing alloy." They are named TEC and TEC-Z and their flow points are intermediate between soft solders and silver-brazing alloys. Joints made by these alloys are strong in straight tension or shear. For instance, butt joints of cold-worked copper can be made having a tensile strength of about 25,000 psi. This is approximately 10,000 psi. more than can be obtained with tin-lead soft solders. TEC joints retain their strength at elevated temperatures much better than the tin-lead soft solders. As shown in the table below, the strength of the solder itself at 425° F is about the same as a 50% tin–50% lead solder at room temperature in short-time tensile tests.

Applications—One example is a thermostatic bellows where the operating temperature is too high for soft solders (tin-lead), yet requires a joining medium which will not anneal the bellows. Another use is gun parts which require joint strength at higher than soft-solder operating temperatures *plus* corrosion resistance to solutions used in cleaning and blackening. Also for lamp bulb bases operating at approximately 350°-500° F. Automotive applications and heat exchangers. TEC conforms to Government Specifications Mil-S-19234 (Nord); both TEC and TEC-Z are available in sheet, wire, powder, and preforms to specifications.

NOMINAL COMPOSITIONS

	TEC	TEC-Z
Silver	5% plus or minus 0.5%	5% plus or minus 0.5%
Zinc		16.6% plus or minus 0.5%
Cadmium	95% plus or minus 0.5%	78.4% plus or minus 0.5%

PHYSICAL PROPERTIES

	TEC	TEC-Z
Color	White	White
Melting Point	640° F	480° F
Flow Point	740° F	600° F
Density (Troy oz/cu in.)	4.60	4.53
Electrical Conductivity (Cu=100)	22.0%	20.6%
Electrical Resistivity (Microhm-cm)	7.9	8.4

STRENGTH COMPARISON TEC vs. Pb-SN

	TENSILE STRENGTH LBS/SQ IN. TEC	TENSILE STRENGTH LBS/SQ IN. Pb-SN
ROOM	16,400	2,500
300° F	4,400	650
425° F	2,600	Melts
500° F	1,700	

The information and data on this page are available in our Handy Alloy Data Sheet. Ask for "TEC." Handy & Harman, 82 Fulton Street, N.Y.C. 38.

Your No. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

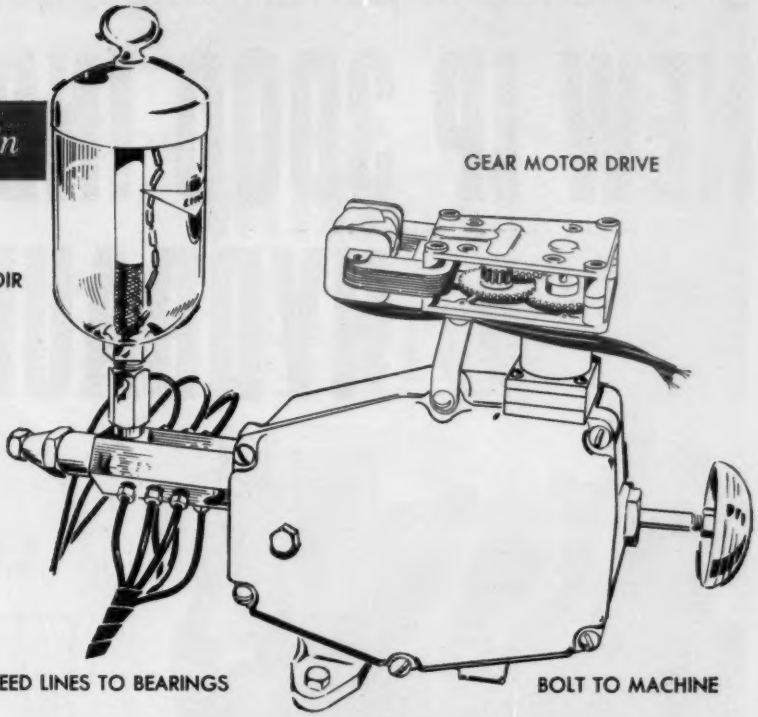
General Offices: 82 Fulton St., New York 38, N. Y.

Offices and Plants: Bridgeport, Conn. • Chicago, Ill. • Cleveland, Ohio • Dallas, Texas • Detroit, Mich. • Los Angeles, Calif. • New York, N.Y.
Providence, R. I., • Montreal, Canada • Toronto, Canada

DISTRIBUTORS IN PRINCIPAL CITIES

Circle 476 on Page 19

Design tips from Lincoln



Simple Gear Motor on Ratchet Multi-Luber® makes Automatic Electric Lubrication System

You can use a simple gear motor to drive Lincoln's new ratchet Multi-Luber to get a simple, low-cost electric lubrication system for light machinery of all types. Gear motor ratios of 1, 2, or 3 rpm and ratchet Multi-Luber ratios of 25:1, 50:1 and 100:1 let you choose the lubrication interval best suited for the machine.

The gear motor can be wired to any 110V/AC circuit so that the Multi-Luber provides lubrication whenever the machine is running. With standard setting, the Multi-Luber discharges 0.0025 ounces of lubricant (grease or oil) from each of the 12 outlet ports every time it cycles. Output of the first four ports can be doubled. The gear motor installs easily . . . you need only a clutch plate for the 3/16" output shaft and a mounting bracket.

You can use the gear motor if rotating or reciprocating motion is not available to drive the ratchet arm or if remote location of the lube unit is desirable to protect it during steam or caustic cleaning.

Multi-Luber units on cottage cheese packaging machines are giving these advantages according to the manufacturer: protect bearings against water contamination during steam cleaning, eliminate product contamination by lubricant, eliminate removal of protective side panels to manually lubricate, provide constant film lubrication on bearings. They have also extended the manufacturer's field service check from 90 to 120 days.

Note to Manufacturers:
Lincoln assists manufacturers in adapting automatic lubrication system to machinery . . . contact Lincoln's Original Equipment Sales Division.

LINCOLN ENGINEERING COMPANY
Original Equipment Sales Division
4010 Goodfellow Blvd., Dept. MP-1
St. Louis 20, Mo.

☐ Please send operating data sheet and Catalog 50 on Multi-Luber.
☐ Have your representative call to advise me on Multi-Luber adaptation to my machines.

Name_____ Title_____
Company_____
Address_____
City_____ Zone____ State_____

C6102

LINCOLN ST LOUIS

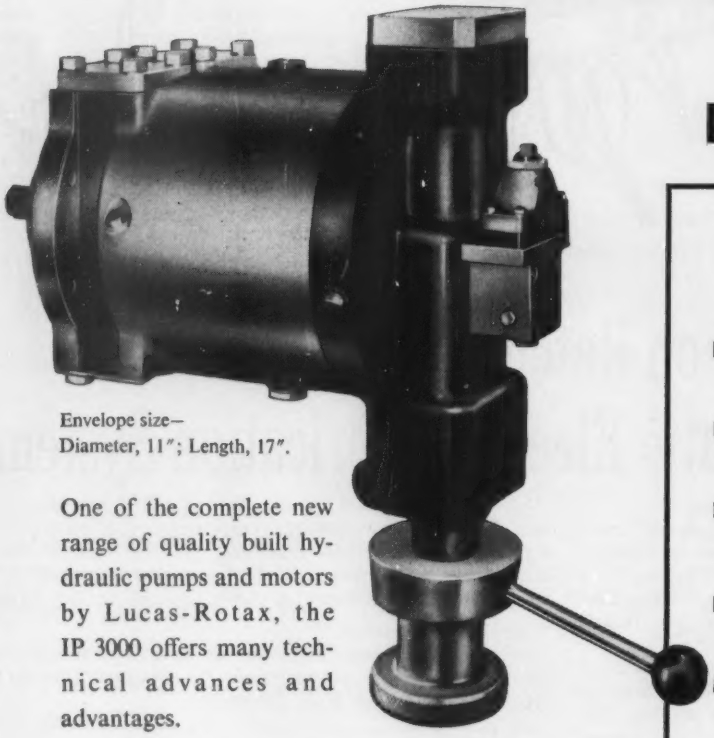
LINCOLN
ENGINEERING COMPANY

ST. LOUIS 20, MO. • DIVISION OF THE McNEIL MACHINE & ENGINEERING CO.

Unmatched in performance, quiet... the reliable

NEW IP 3000 INDUSTRIAL HYDRAULIC PUMP

by LUCAS-ROTAX



Envelope size—
Diameter, 11″; Length, 17″.

One of the complete new range of quality built hydraulic pumps and motors by Lucas-Rotax, the IP 3000 offers many technical advances and advantages.

- **Smaller size**
- **Lower weight**
- **Variable volume**
- **Low noise level at higher operating speeds**
- **Low cost**
- **High efficiency**
- **Fitted with pressure compensator as standard equipment**

For further information, contact the agent or office nearest you today, or write for technical literature.

PUMP DETAIL

	Basic Pump Fixed Stroke
Fluid displacement (cub. ins./rev.)	13.89
Nominal working pressure (peak)	5000
(lb. per sq. in) (continuous)	3000
Nominal speed (peak)	2000
(r.p.m.) (continuous)	1800
Input h.p. at 1,000 r.p.m. and 1,000 lb. per sq. in. differential	38
Max. Torque (lb./ft.) per 1,000 lb. per sq. in. fluid pressure differential	200
Recommended Inlet Pressure (p.s.i.g.)	60
Weight (lb.) Basic Pump	128
Operating temperature	−40 to 200°F

a product of creative engineering by

For further information contact U.S. Representative:
JULIUS KENDALL,
Kenett Corporation, 320 Washington Street Brookline 47, Mass. LOngwood 6-0378

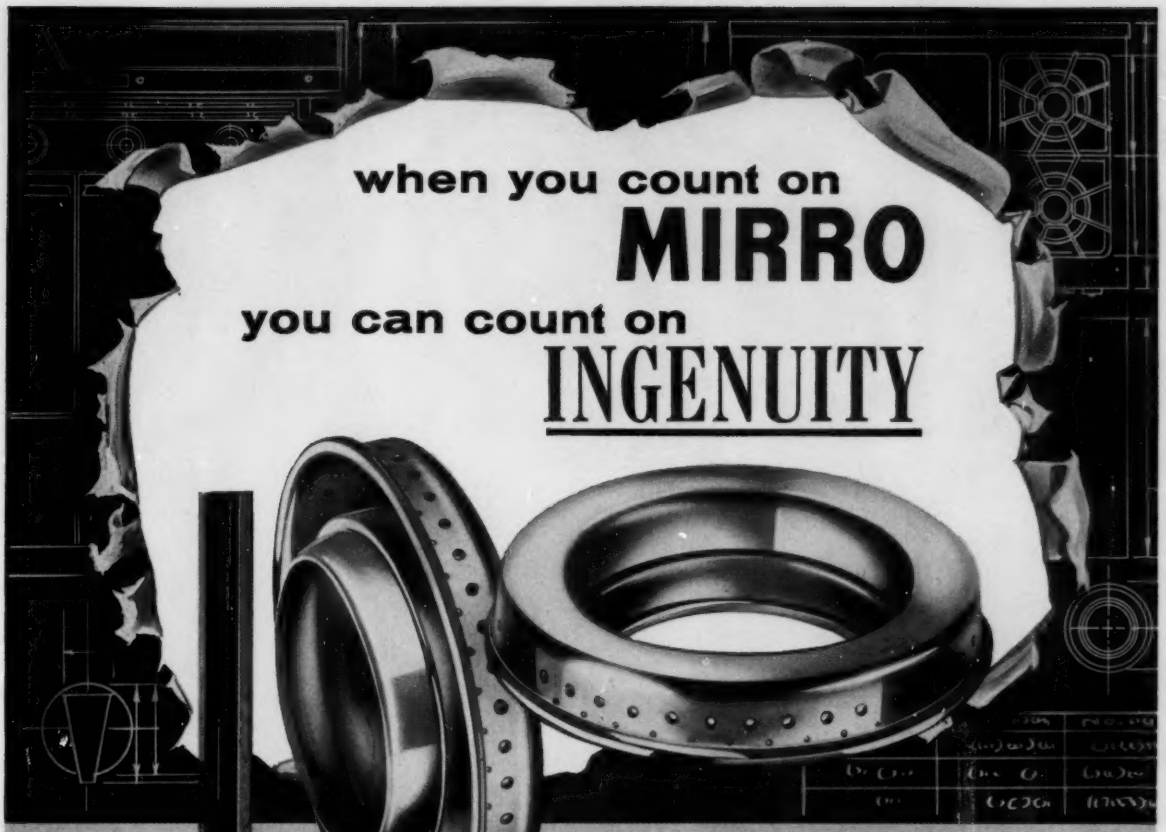
LUCAS-ROTAX
LIMITED, TORONTO

LUCAS ROTAX

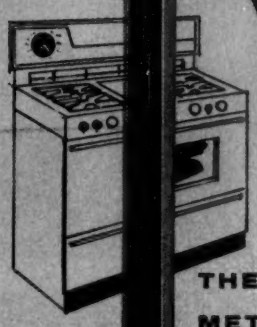
A member of the Lucas organization
WITH OFFICES AND SERVICE DEPOTS THROUGHOUT NORTH AMERICA

BOSTON • NEW YORK • CHICAGO • LOS ANGELES • HOUSTON • SAN FRANCISCO • CLEVELAND
JACKSONVILLE • DENVER • SEATTLE • BALTIMORE • TORONTO • MONTREAL • VANCOUVER

6010



when you count on MIRRO you can count on INGENUITY



THE METAL MEN OF MANITOWOC

COUNT ON MIRRO for any production line requiring aluminum components...appliances, housewares, automotive, or Government contracts.

MIRRO
THE FINEST ALUMINUM

This gas range burner ring, for a manufacturer of '61 Gold Star models, is a case in point. It's a demanding piece to make. Shoulder tolerances must be held within .005" level. Each gas outlet port must direct flame at a *precise* angle. The smaller series of ports asks the theoretically "impossible," by requiring a diameter smaller than the gauge of the metal itself. And it must function consistently in all temperatures, from a dead-cold start to flame-heat.

MIRRO ingenuity devised the dies and draws, noodled out the indexing equipment for series punching of outlet ports, and supplies the completed piece in volume, meeting the tough A.G.A. laboratory standards at a practical price.

There's a whole lot back of a job like this. Years of aluminum know-how. Highly capable engineers and designers. MIRRO's own rolling mill and metallurgical staff. Complete finishing facilities. Rigid quality control. And the constant awareness that pennies saved mean dollars earned, on any high-volume contract.

Count on MIRRO and you can count on *all* of that, backing any contract job you place with us. We'd welcome a chance to estimate or advise.

MIRRO ALUMINUM COMPANY, MANITOWOC, WISCONSIN

Fifth Avenue Bldg., New York 10
Merchandise Mart, Chicago 54

Let a J-M friction specialist help you solve complex "stop and go" problems

J-M SMALL MOLDED PARTS, MANY FEATURING UNITIZED CONSTRUCTION, ARE CUSTOM-DESIGNED TO YOUR EXACT NEEDS

One sure way to improve performance in small brakes and clutches is to call on the free advice of a Johns-Manville Friction Specialist. He's an expert in the design and construction of small parts that increase efficiency in "stop and go" actions. He is prepared to discuss your specific problems...and, where conditions permit, work J-M's unitized construction into your plans.

At his command is a wide range of asbestos-based friction materials, especially developed for small molded parts. These organic compositions meet virtually any requirement. If, for example, you need drive clutches, torque limit clutches, or small brakes – J-M MINI-BLOKS® are made of ideally suited materials. Precision-molded MINI-BLOKS offer high friction, light weight, high temperature resistance, and a long service life that is free of trouble.

The advice and help of a Johns-Manville Friction Specialist are yours for the asking. Just tell him the part you need and the characteristics you require. He'll take it from there. Write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario. Offices throughout the world. Cable address: Johnmanvil.

JOHNS-MANVILLE JM PRODUCTS

Circle 480 on Page 19

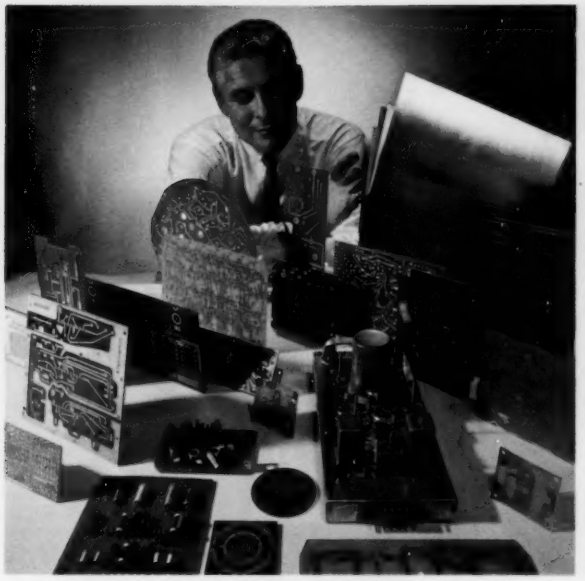
Circle 481 on Page 19→

116 reasons why we can help you put your finger on the right plastic faster

85 PHENOLITE® laminates...

3 thermoplastics—nylon, DELRIN,* PENTON†

16 grades of Vulcanized Fibre...



12 grades for printed circuits...

This will give you an idea of how surely National can help you pinpoint exactly the plastic you want. National has the broadest line in the industry, including standard forms, precision-fabricated parts, and a huge stock of many grades ready for immediate shipment. For fast help, samples, or more information, contact your nearby NVF sales office. You'll find the 'phone number in Sweet's Product Design File 2b/Na. Or write NVF, Dept. TT, Wilmington, Del. It's a direct line to the one best material per dollar of design performance.

NVF

NATIONAL VULCANIZED FIBRE COMPANY
WILMINGTON 99 DELAWARE
In Canada: NATIONAL FIBRE COMPANY OF CANADA, LTD., Toronto 3, Ontario

* DELRIN IS A DU PONT TRADEMARK FOR THEIR ACETAL RESIN • † PENTON IS A HERCULES TRADEMARK FOR THEIR CHLORINATED POLYETHER RESIN

Solve Multi-Point Temperature Control Problems...

at ⅔ cost of competitive systems

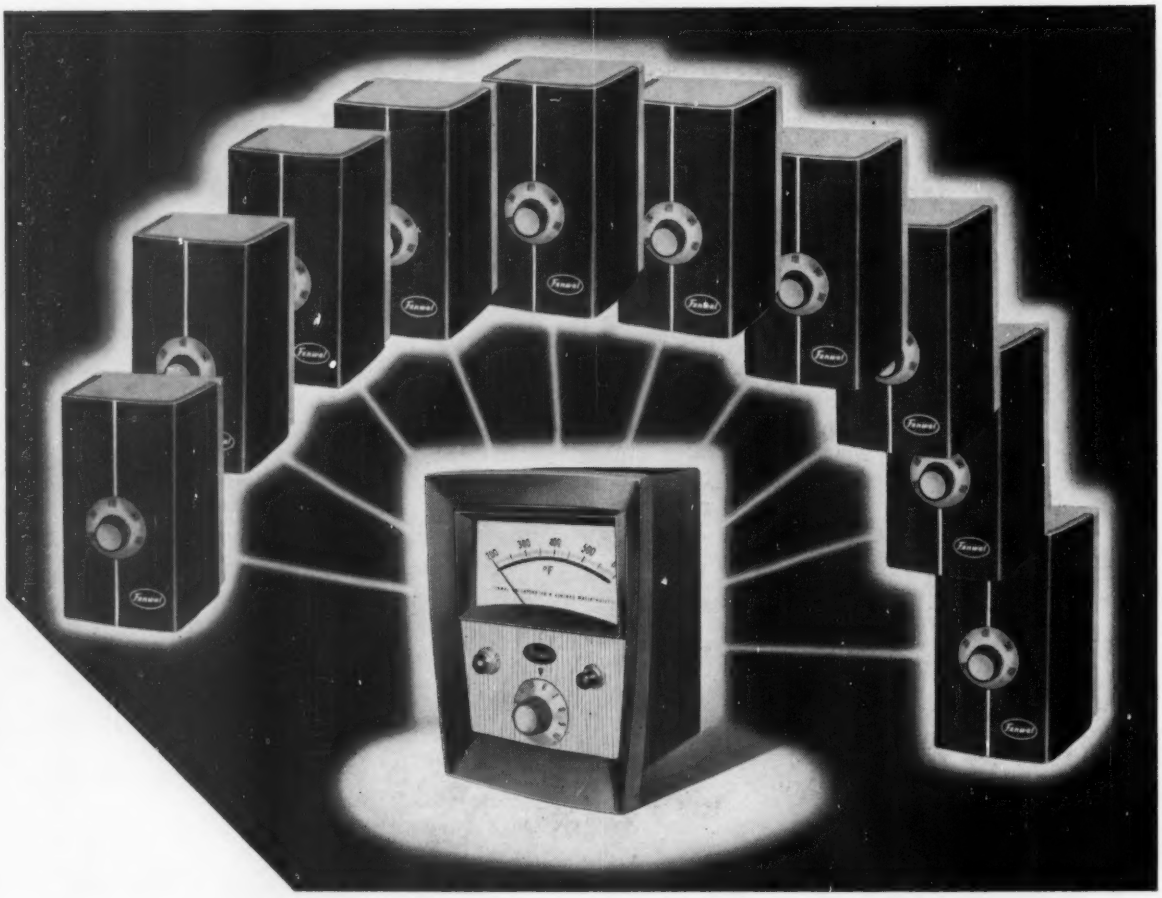
You get them all — wide ranging versatility . . . maximum sensitivity . . . easy installation and servicing! These features *combine* in a Fenwal 536-580 multi-point monitoring system to give you precise, transistorized temperature control and indication. And *you choose the features you need to suit your own requirements!*

Examine these cost saving advantages: Indication and control circuits are separate . . . the 536-580 system eliminates the need for separate indication and control at each point. You can build a control system concurrent with your needs — start with 2 points and build up to 10 points without paying a premium at the outset. The complete control system is built from *standard* catalog parts, thereby eliminating the need to buy costly "specials" for servicing at a later date.

Individual points can have either proportioning or ON/OFF control modes. The system permits "flick of switch" indication of from 2 to 10 temperatures. Individual set points can be adjusted from a central control panel or through a separate potentiometer remotely located. You select your own number of points and you *pay only for the options you use.*

Choose from five standard temperature ranges — from −50 to 600°F . . . expanded scales permit fine temperature adjustments and improved readability, and *the entire system gives you sensitivity to within 0.1°F.*

Both instruments are smartly styled to perfectly complement modern industrial machines and interiors. A Fenwal engineer will be glad to supply information on this system, or any other temperature control in Fenwal's broad line. Write Fenwal Incorporated, 193 Pleasant Street, Ashland, Mass.



Another example of how **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

Cylinder ports side and bottom tapped, ⅜, ½ or ¾ in. NPT; through ports tapped both ends and bottom, supply—1 in. NPT, exhaust and wiring conduit ports—1¼ in. NPT; meets JIC Standards.

to save space . . .

to simplify piping and wiring

New PDQ MODULAR MANIFOLD BASE

Now you can save even more space by ganging already-compact Hunt ½ in. PDQ valves on modular manifold bases!

Featuring common supply, exhaust and wiring conduit ports, PDQ modular manifold bases can be ganged end-to-end to manifold two or more valves in a single, compact assembly. Manifolding of valves simplifies supply and exhaust piping, reduces installation costs and minimizes mounting space requirements for multiple valve installations. Modular design permits adding or removing valves at a later date, to meet changing requirements. Also, bottom tapping permits additional supply, exhaust, or wiring connections at any point along the manifold assembly, if required.

Electrical connections, valve-to-base, are plug-in, to reduce downtime to a minimum. What's more, the bayonet-lock construction of Hunt's PDQ valve allows removal and installation of valve and pilot assembly in just 30 seconds, without disturbing piping or wiring.

Whether your problem is limited valve mounting space . . . complex piping . . . high installation costs . . . or you're just looking for better, lower cost, more dependable performance on new or existing equipment, ask your nearby Hunt representative to show you the advantages of modular manifold base-mounted PDQ valves.

HUNT

QUICK-AS-WINK® AIR AND HYDRAULIC

VALVES

HUNT VALVE COMPANY • DIVISION OF IBEC • SALEM, OHIO

For more information, write for Bulletin 602. Address Hunt Valve Company, Salem, Ohio, Dept. MD-361.

3014

Function Factor formula developed to assess working quality of thread-cutting screws

Unbiased laboratory tests demonstrate superior performance of Parker-Kalon thread-cutting screws in cast iron, steel, aluminum and plastics.

To compare the actual working quality of thread-cutting screws under laboratory conditions, a series of simple yet thoroughly dependable tests were made using P-K Types "F" and "B-F" and competitive thread-cutting screws. These tests can be easily duplicated by any engineering department that would like to determine their own results.

The test was based on the premise that (1) the better a screw resists failure after being driven home, the stronger the assembly, (2) the easier the screw is to drive, the less wear there will be on driving tools and upon the operator and (3) thread failures either on the screw or in the work, gives rise to costly, time-consuming salvage operations as well as other intangible production costs.

Thus, a measure of evaluating the performance of thread-cutting screws is the ease of driving combined with the degree of resistance to fastener failure. The relationship between these two functions is referred to as "drive-strip ratio."

How the tests were conducted

Random sizes of samples purchased on the open market from a variety of sources (including the P-K Types "F" and "B-F") were identified solely by letters. Manufacturer's names were not revealed to the technicians who were responsible for making the investigation.

As a means of fairly evaluating the performance of the screws, they were applied under identical conditions in sections of cold rolled steel, cast iron, aluminum castings and general purpose plastics. Similarly, hole sizes as well as depth of penetration of the screws were identical.

Each screw was driven by a specially designed Detroit torque testing machine.

To limit and control depth of penetration, washers were placed under the screw heads. Screws were inserted in the hole in the part (steel, cast iron, aluminum, plastic) and the part placed in the jaws of the machine. The screw was driven until it cut a full depth thread. The maximum driving torque was recorded at this point.

Failure Point The second phase of the test was to determine the amont of torque which could be applied to the fastener before (1) the screw failed in section or (2) when the screw failed in the engagement material. This failure point was then recorded in inch-pounds, whereupon a direct comparison of the several screws could be made.

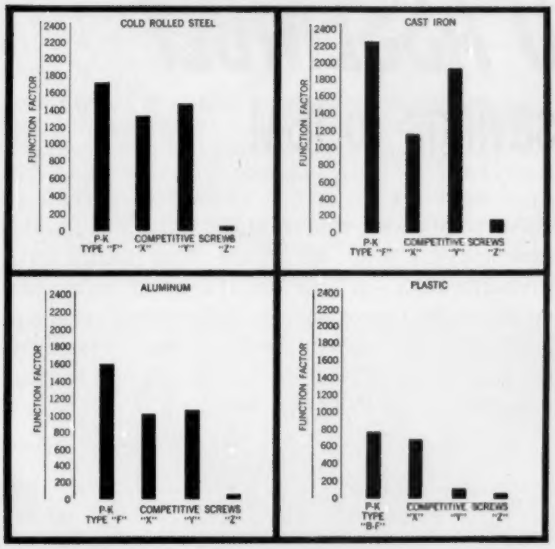
Function Factor In order to assess the working qualities of each screw that was tested, a formula was devised that would express these functions. DRIVE TORQUE was the average of driving torque values obtained from individually running a given number of screws in the application. STRIP TORQUE was the average of a given number of strip torque values obtained from the ultimate failure of the screws in section or of the threads in application.

Formula The formula is expressed as

$$\text{Function Factor} = \frac{(\text{Strip Torque})^2}{\text{Drive Torque}}$$

P-K® thread-cutting screws average 108% better working qualities than the 3 competitive types tested.

Charts shown are typical samples and represent in each case only one of the many tests run on each screw. Identification of screws tested was made only upon completion of test.



Designed to reduce pressure development in the engaging section by as much as 80%, P-K Types "F" and "B-F" thread-cutting screws are manufactured with five cutting flutes. The completely formed threads have sharper cutting edges and flutes are of continuous depth.

Lower Drive Torque

Together these new P-K features make for better clearance of the accumulated material and *assure lower drive torque*. They also sharply reduce the possibility of stripping, galling and other causes of screw failure.

Use Recommendations

P-K TYPE "F"

P-K TYPE F The new, improved P-K Type F (Patented), is a hardened thread-cutting screw developed for use in granular or brittle materials such as ferrous or non-ferrous castings and bronze or brass forgings. It may also be used advantageously in structural steel and sheet metals when it reduces driving torque and resists shear and tension loads and in impregnated plywoods where it grips with rugged strength. The pilot with its five tapping flutes cuts a machine thread as the screw is turned in—does the job with complete dependability—stays tight and secure.

P-K TYPE "B-F"

P-K TYPE B-F For plastics, P-K recommends the new improved "Pentap", Type B-F (Patented). This exceptionally efficient thread-cutting screw combines the five thread-cutting flutes of the P-K Type F with the coarse-pitch, widely-spaced threads of the P-K Type B screw. Thus it distributes cutting pressure evenly, lets chips drop to the bottom of the hole and prevents cracking of the material. The B-F is designed for making fastenings to comparatively thin sections and bosses in friable and brittle plastics.

SPECIAL FOR NYLON P-K TYPE L

P-K TYPE "L"

For this very popular material, only Parker-Kalon has a completely new tapping screw—especially developed for use in nylon. It is called the P-K Type L (U.S. Patent 2,350,346). The Type L functions as a combination thread-cutting and thread-forming screw in that it cuts a small amount of nylon while allowing the full diameter of the threads to form. The new P-K Type L offers a particular advantage in nylon assemblies which must be disassembled for service because the Type L can be readily removed and replaced without stripping or galling.

USING THREAD-CUTTING SEMS?

SEMS

Specify P-K, and get thread-cutting screws with a higher drive-strip ratio, *plus* the added holding power of a pre-assembled washer!

P-K Sems are readily available with a wide variety of washers pre-assembled to thread-cutting screw types "F" and "B-F". They may be ordered with slotted, Phillips or Hex heads. They can be hopper fed for automatic driving. Inspection rejects due to omitted lock washers are impossible. Fastenings stay tight and firm.

P-K Sems reach your assembly line pre-assembled, ready for instant use. They assure concentric washer seating—washers cannot come off. Double inventory and parts handling is completely eliminated.

P-K Sems are also available with a wide variety of washers pre-assembled to thread-forming and machine screws.

Use the Function Factor formula and prove to yourself that Parker-Kalon thread-cutting screw types F and B-F consistently perform at a higher drive-strip ratio. Their use will increase production efficiency and reduce the "in-place cost" of fasteners in assembly operations. Production run samples may be obtained from your P-K Distributor, or write direct to the Parker-Kalon Sales Engineering Department.

PARKER-KALON *fasteners*

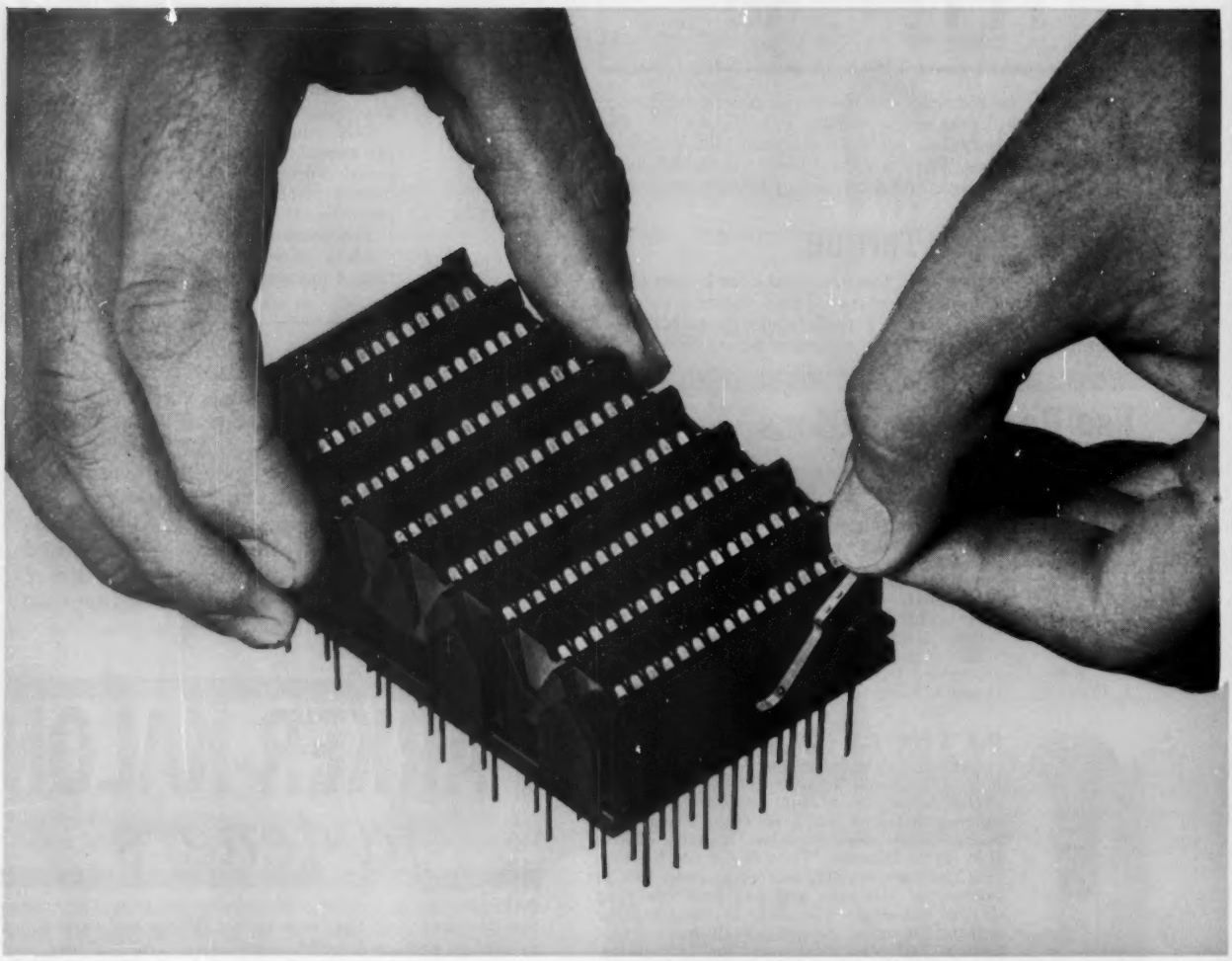
PARKER-KALON, a division of General American Transportation Corporation, Clifton, New Jersey. Offices and warehouses in Chicago and Los Angeles.

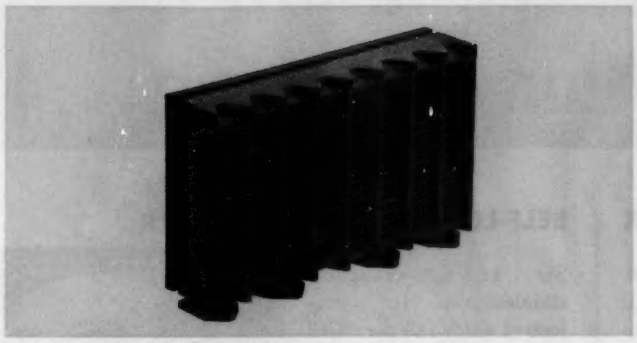
SYLVANIA PRODUCES & DELIVERS THE COMPLETED ASSEMBLY

—at substantial savings to IBM

This electrical connector block is a vital link in the electrical system of an IBM computer. Unless it is built to exact tolerances, the computer can malfunction.

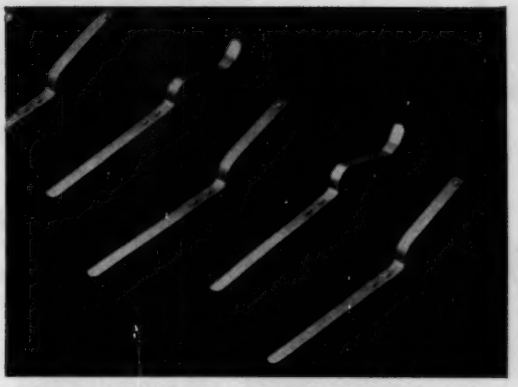
To make this critical part, IBM chose Sylvania because we could perform the entire production sequence—from raw materials to completed assemblies built to tolerances in terms of thousandths of an inch. It soon proved the Sylvania experience paid off in two ways: in production economies and in fast delivery too. Total result: a better connector block—at lower cost. (For details see captions to pictures on these pages.) For full information on how Sylvania custom facilities can benefit *you*, or for a quote on a specific project, write Sylvania Electric Products Inc., Parts Division, Warren, Penn.





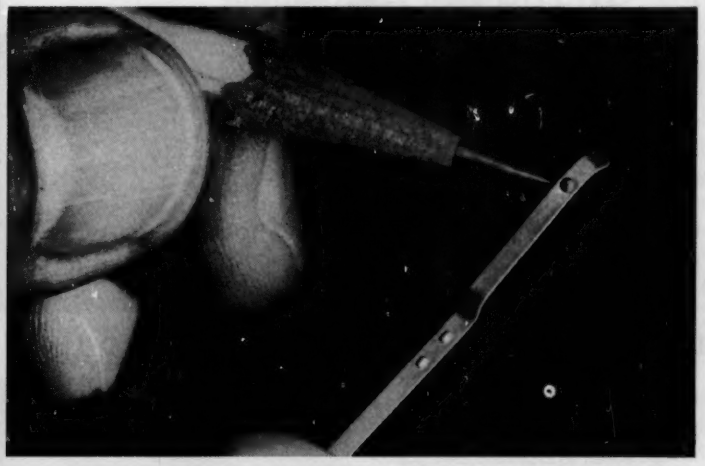
MOLDED FROM PLASTIC by Sylvania, the IBM connector block meets tightest specifications. This is possible because Sylvania maintains one of the world's most modern and complete lines of automatic molding equipment. This equipment permits Sylvania to handle volume orders for compression, injection and transfer molding. And a unique bank of rotary presses can produce millions of precision parts each day—even using phenolics and urea.

Result to IBM? Precisely formed parts to fill high-volume requirements.

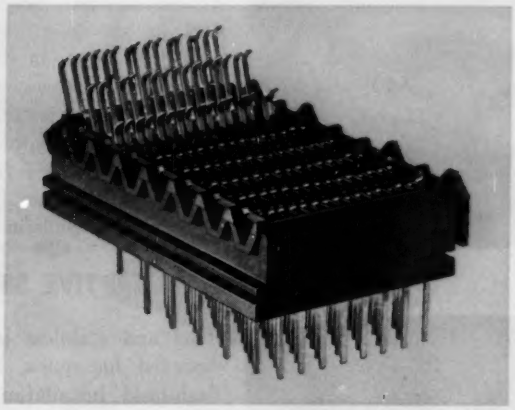


MADE FROM SYLVANIA WIRE, precision-rolled ribbon connectors offer high reliability when the circuitry is completed using wire wrap contact methods. The cross section of the ribbon—.023″ x .062″—and the corner radius of .003″ were accomplished on a special three-head tandem rolling mill and special forming equipment.

Result of this flexibility to IBM? Top reliability at close tolerances.



CUSTOM METAL STAMPING AND DOT WELDING, in one operation, also paid big dividends to IBM. The original plans called for forming parts and then gold-plating the entire contact. Following a request by IBM to extend contact life and reduce costs, Sylvania experience paid off. Sylvania Engineers demonstrated they could weld a tiny gold dot at the contact point economically while maintaining close tolerance on the critical dimensions of the formed contact. High-speed, high-volume techniques enable Sylvania to meet critical deflection and sheer tests. Sylvania maintains a metal stamping facility which includes multi-slide machines, vertical presses, and specially developed machines to help solve your special problems.



CUSTOM ASSEMBLY by Sylvania of the block and the parade of contacts is handled by our corps of trained specialists. Many of our customers have found that Sylvania can often deliver completely assembled and packaged products—using either all Sylvania components or all customer components, or both—*at lower cost than is possible in the customer's own facilities.*

Result to IBM? Many, many thousands of completed top-quality assemblies per month, and to tolerances specified for automatic wire wrap.

QC SERVICE MEANS QUALITY CONTROL!

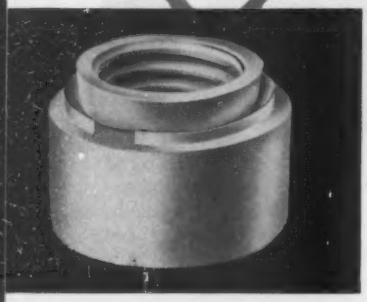
At Sylvania, a tough-minded, hard-to-please quality control department has full authority for assuring the parts Sylvania produces meet your most stringent specifications. Example of this thoroughness: for the IBM connector block, Sylvania used *100% inspection!*

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

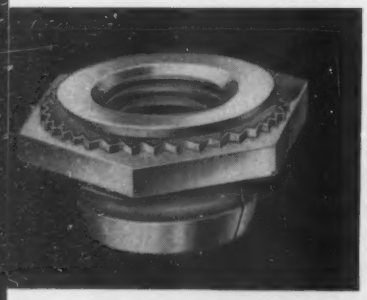
PEM CAPTIVE THREADS for Production Fastening...

THE ORIGINAL SELF-CLINCHING FASTENER



Made in steel, stainless steel, aluminum and Monel. Positively locked into prepared holes by any standard squeezing tool. For metal thicknesses down to .032". Sizes from No. 0 to ¾". Bulletin CL.

SELF-CLINCHING, SELF-LOCKING NUT

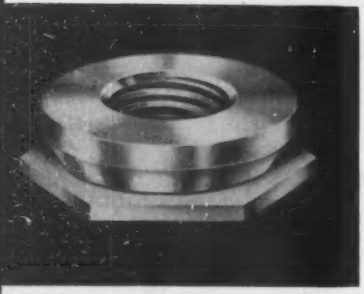


All metal (steel, stainless steel or aluminum) combines 2 functions in single light-weight, low-cost unit for sheet metal fastening. Suitable for installation in sheet thicknesses from .040" and up. Sizes from No. 2 to 10. Bulletin SL.

SELF-CLINCHING CAPTIVE STUD

Steel and stainless steel, designed for quick, easy flush-head installation in panels of cold-rolled steel, brass, copper, aluminum alloys and similar materials. Sizes No. 4 to 5/16". Lengths from ¼" to 1½". Bulletin FH.

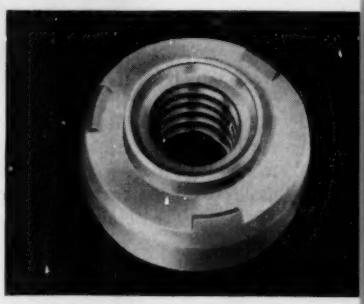
SELF-CLINCHING FLUSH FASTENER



One-piece, stainless steel threaded insert installs in sheet thicknesses from .061" and up with flush mounting area on both sides of sheet. Suitable for materials with Rockwell Hardness of B-70 and less. Sizes No. 2 to ¼". Bulletin FH.

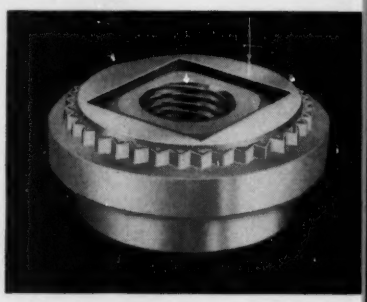
SELF-LOCATING WELD FASTENER

Steel and non-magnetic stainless steel. Nut is projection welded to part with extended shank protecting threads from weld splatter and serving as pilot in assembly. No. 2 to ¼". Bulletin WN.



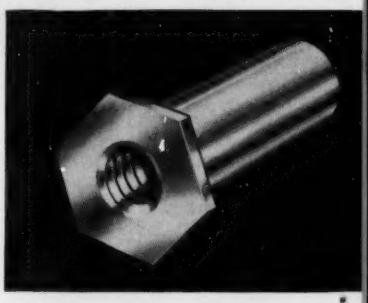
SELF-CLINCHING FLOATING NUT

Carbon steel and stainless steel. Provides rapidly assembled nut anchor in sheet metal and compensates for slight errors (up to ½") in alignment of mating holes. Sizes No. 2 to ¼". Suitable for sheet thicknesses from .040" up. Types AS and AC.



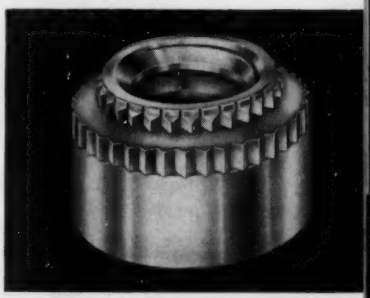
SELF-CLINCHING STAND-OFFS

Made in both blind and threaded-through types in steel, aluminum and stainless steel. Sizes No. 4 and No. 6. Overall lengths from ⅛" to 1 1/16". Suitable for use in sheet thicknesses from .040" and up. Bulletin SO.



SELF-CLINCHING SPLINE FASTENER

For hard metals and brittle materials — magnesium, glass laminates, epoxies, etc. Made in steel and stainless steel. Sizes No. 2 to ⅜". Type KF.



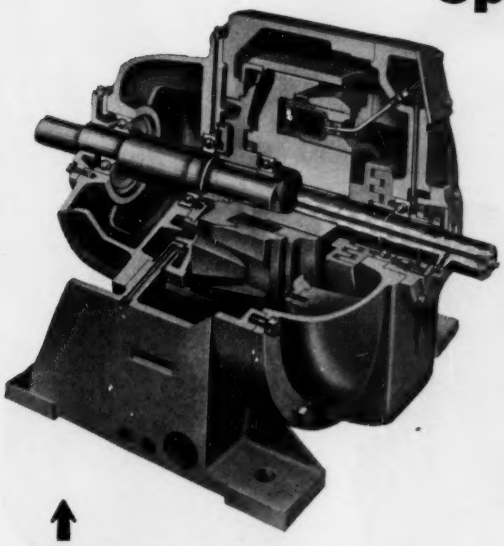
Circle 486 on Page 19

PENN ENGINEERING & MANUFACTURING CORP.

DOYLESTOWN • PENNSYLVANIA

NEW YORK (BELLE HARBOR, L.I.)—NEPTUNE 4-7103
CINCINNATI—GRANDVIEW 1-9011
CHICAGO (FOREST PARK, ILL.)—FOREST 6-4971
INDIANAPOLIS—CLIFFORD 1-4020
DETROIT—UNIVERSITY 3-5189
TOLEDO—GREENWOOD 4-9563
MIAMI—TUXEDO 5-3147
MILWAUKEE—BLUEMOUND 8-6118
MINNEAPOLIS—GREENWOOD 4-6203
DALLAS—FLEETWOOD 7-5713
LOS ANGELES—BRADSHAW 2-8097

The BEST Solution to Difficult Speed Control Problems—

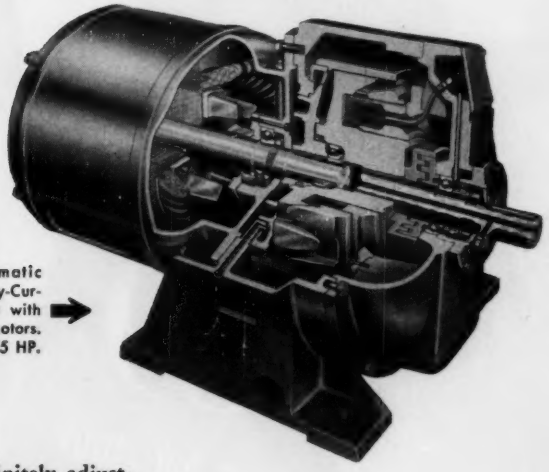


Dynamatic Liquid-Cooled Couplings provide infinitely adjustable speeds for nearly every application from 3 to 75 HP. Note the absence of slip rings, brushes, and commutators. Heavy-duty types with capacities up to 5,000 HP are also available.

EATON

DYNAMATIC®

LIQUID-COOLED EDDY-CURRENT COUPLINGS and DRIVES



"Dynaspede" Drives are Dynamatic Liquid-Cooled, Stationary-Field Eddy-Current Couplings mounted integrally with standard, D-flange, squirrel cage motors. Available in capacities from 3 to 75 HP.

Here's Why—

Dynamatic Liquid-Cooled Couplings and Drives provide infinitely adjustable speed from a constant speed source—or constant speed from a variable speed source. They operate on standard alternating current. Rotary power is transmitted through the coupling by an electromagnetic reaction between the driving and driven members of the unit—there is no mechanical contact of rotating members to cause wear and require adjustment or replacement.

A wide range of standard and special control features may be obtained from a remotely-mounted electronic control system. Infinite speed adjustment, constant speed control, on-off clutch control, torque limit, acceleration control, inching, and threading are a few of the many functions available. The addition of an eddy-current brake to standard couplings or drives provides smooth, cushioned stops and controlled deceleration.

Liquid-Cooled Dynamatic Couplings and Drives deliver more horsepower than other types of the same physical size, thus conserving space in a busy machine area. Efficient heat dissipation permits continued operation at low speeds, or stall with full load.

Completely enclosed, Dynamatic liquid-cooled units are protected from dust, dirt, and other atmospheric impurities. Dynamatic design involves no brushes or slip rings; there is no possibility of arcing. With simple modification these units can be made explosion-resistant for hazardous applications.

Infinitely Adjustable Speeds from AC Power

★

Full-Torque Starts

★

Wide Range of Control Functions

★

No Slip Rings, Brushes or Commutators

★

Completely Enclosed Design

★

Greaseable Bearings

Send for Our New Illustrated Bulletin.

EATON MANUFACTURING COMPANY

DYNAMATIC DIVISION

3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

Champion Upset Forging Cuts Finished Gear Cost 23%!

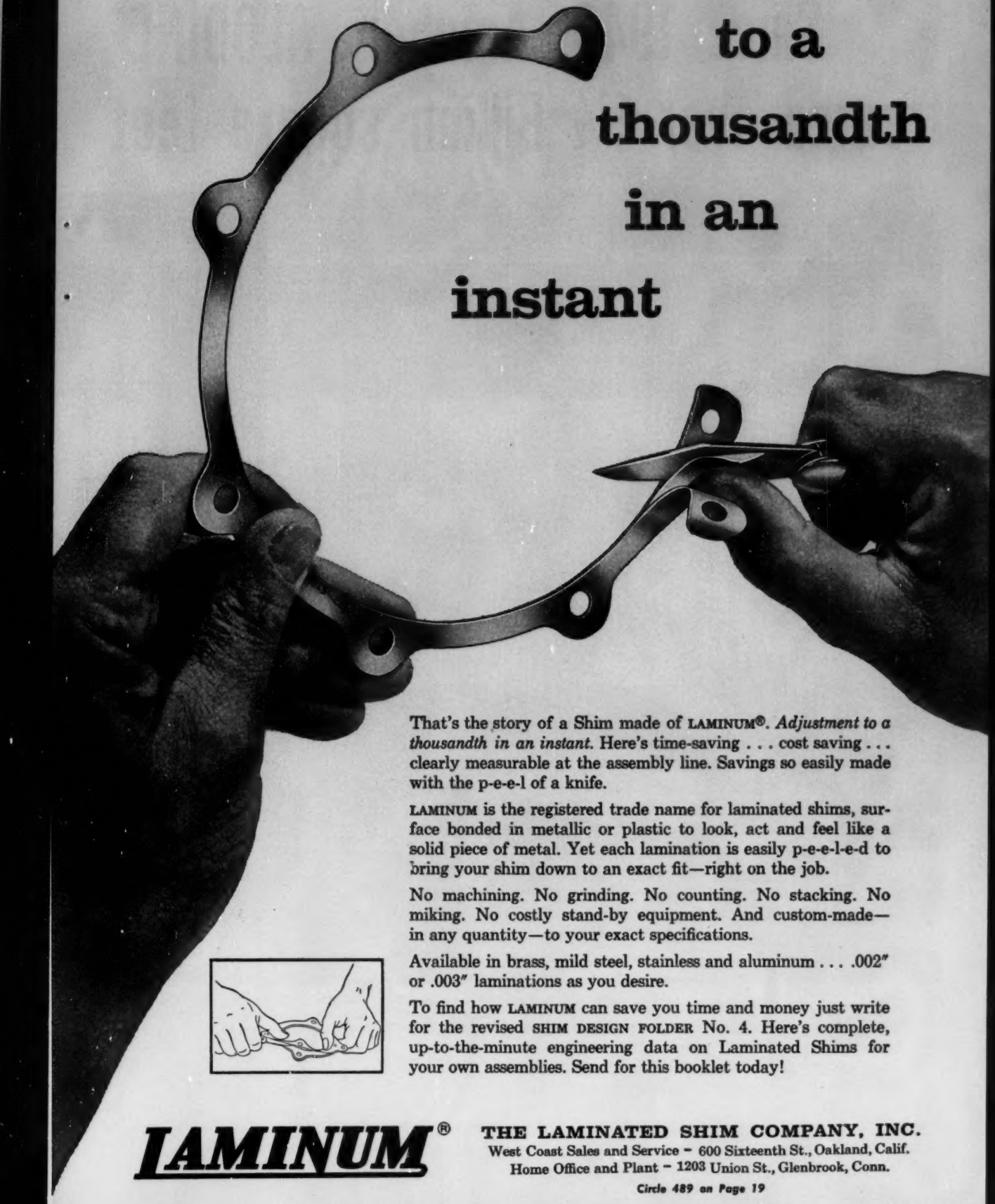
The manufacturer of this pinion gear cuts finished cost 23% by starting with Champion upset forged blanks. He saves on material by using a $1\frac{1}{64}$" x 5" blank with a $1\frac{3}{4}$" collar instead of $1\frac{3}{4}$" bar stock. He saves again because most rough machining is eliminated.

Upset forgings can save you money and give you better quality too . . . upsetting increases strength by directioning grain flow in the metal. Check your products for parts like this . . . then call —

THE CHAMPION RIVET COMPANY
T. P. Champion, President
CLEVELAND 5, OHIO • EAST CHICAGO, INDIANA

When it's a vital part, better make it **FORGED**

Adjustment to a thousandth in an instant



That's the story of a Shim made of LAMINUM®. *Adjustment to a thousandth in an instant.* Here's time-saving . . . cost saving . . . clearly measurable at the assembly line. Savings so easily made with the p-e-e-l of a knife.

LAMINUM is the registered trade name for laminated shims, surface bonded in metallic or plastic to look, act and feel like a solid piece of metal. Yet each lamination is easily p-e-e-l-e-d to bring your shim down to an exact fit—right on the job.

No machining. No grinding. No counting. No stacking. No miking. No costly stand-by equipment. And custom-made—in any quantity—to your exact specifications.

Available in brass, mild steel, stainless and aluminum . . . .002″ or .003″ laminations as you desire.

To find how LAMINUM can save you time and money just write for the revised SHIM DESIGN FOLDER No. 4. Here's complete, up-to-the-minute engineering data on Laminated Shims for your own assemblies. Send for this booklet today!

LAMINUM®

THE LAMINATED SHIM COMPANY, INC.
West Coast Sales and Service - 600 Sixteenth St., Oakland, Calif.
Home Office and Plant - 1203 Union St., Glenbrook, Conn.

Circle 489 on Page 19

Take a lead from the leaders...

Since 1948, Amchem ALODINE* treated over 1½ Billion square feet

Popular Reynolds Colorweld pre-finished aluminum panels find wide application in commercial construction where its enduring performance and good looks are helping to change the architectural face of industry. Alodine contributes its protective qualities to Colorweld's amazing paint performance.

Conversion Coating Chemicals have of Aluminum in Reynolds Plants!

From 1955, when Reynolds Colorweld** Production was started, Reynolds has used ALODINE; Continue to Report Complete Customer Satisfaction with Paint Adhesion on this Quality Pre-Enameled Aluminum Product

At two Reynolds producing facilities—Atlanta, Ga. and McCook, Ill.—Alodine chemicals used in the pre-paint treatment of Colorweld offer a typical example of Reynolds' continuing emphasis on product quality.

Each day at these plants thousands of feet of aluminum are treated with Alodine to provide the metal with a chemical coating which produces high quality paint bonding characteristics so essential to the durable Colorweld finish Reynolds demands.

Alodine provided the first economical treatment that made possible the mechanical forming of pre-painted aluminum. Under extremely high volume processing speeds, the outstanding attributes of Alodine benefit aluminum products of all types—through improved paint bonding for subsequent mechanical forming operations, that means extra years of wear for painted aluminum under all types of environmental conditions.

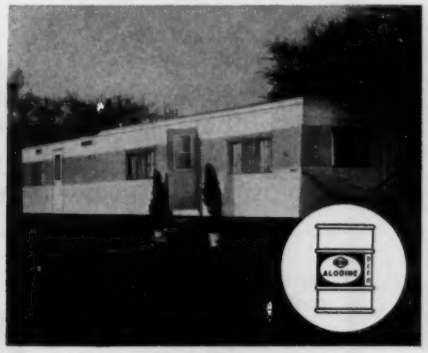
Behind the success of Alodine as the outstanding pre-paint treatment for aluminum stand the research and development activities of Amchem's Metal Protection Laboratories where the search continues for even more efficient aluminum treating chemicals.

Take a lead from the leaders. If you're producing aluminum—bare or coated—specify Alodine for the assured quality and added beauty of your finished product.

*Amchem's registered trademark for its conversion coating chemical for aluminum.

**Colorweld is a registered trademark of the Reynolds Metals Company.

Beauty and durability characterize siding of Reynolds Aluminum Colorweld for home use. Alodine chemicals help provide a paint bond that lasts and lasts.



This home-on-wheels has more appeal, will last longer thanks to its body of Reynolds Aluminum Colorweld, and a firm paint bond thanks to Alodine.

At Amchem's Metal Protection Laboratories exhaustive quality control testing assures the performance of Alodine chemicals for every aluminum pre-paint requirement.

AMCHEM **ALODINE**

Amchem is a registered trademark of
AMCHEM PRODUCTS, INC. (Formerly American Chemical Paint Co.)
AMBLER, PA. • St. Joseph, Mo. • Detroit, Mich. • Niles, Calif. • Windsor, Ont.

Write for Bulletin 1424C, gives detailed technical specifications on different Alodine chemicals available for pre-treating aluminum.

Circle 491 on Page 19

how to pick

the one right SOLID PIN for the job

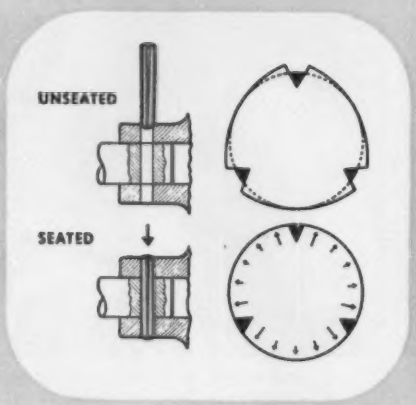
(the solid Groov-Pin is still the safest, surest way to pin two parts together)

The Groov-Pin has the holding power of a press fit pin *without* the need for close tolerances, and the ease of installation of a taper pin *without* the need for reaming.

You just drill the hole and drive the pin home. Once seated it stays there...no matter what the condition of shock or vibration.

Available in low carbon steel or other materials (stainless pins are Type 303, nonmagnetic). Diameters from 1/32" to 1/2" are standard; specials are available and priced as standard in lots above 5000.

Write today for samples, comprehensive catalog, and acetate copy of this ad suitable for wall mounting. Groov-Pin Corporation, 1130 Hendricks Causeway, Ridgefield, N. J.



the unique GROOV-PIN locking principle

When a Groov-Pin is driven, the material displaced by the grooves is forced to flow back, setting up a powerful locking force. The ability of Groov-Pin to hold under severe shock and vibration . . . and its immunity to vibration fatigue . . . has been thoroughly proved by the billions in use!

GROOV-PIN

Circle 492 on Page 19

fastening gears, pulleys, sprockets, collars and cams to shafts.

type 1

The basic Groov-Pin and most widely used. Has three full length grooves tapering from maximum diameter at one end to nominal diameter at the other.

locating pins, stop pins, hinge pins.

type 2

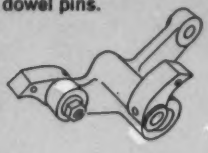
Grooves cover only one half of pin length. Used where holding power is not critical. Speeds assembly because ungrooved portion acts as a pilot.

clutch and brake pedals to cross shaft; bike pedal arms to brake shafts.

type 3

Recommended for severe shock and vibration applications, its full length parallel grooves give it great holding power. Type 3H is essentially the same, but has pilots on both ends suiting it for hopper feeds.

stop pins, locating pins, dowel pins.



type 4

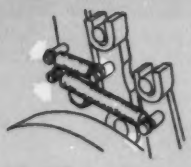
Similar to Type Two, but taper on grooves is reversed, meaning groove end is inserted first. This is particularly good on blind hole applications.

aircraft cowling, cover plates for buses, trucks.

type 5

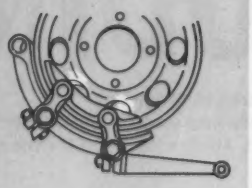
Has three oval grooves half the length of the pin, centrally located. Especially suited for quick removal and replacement. Type Five is also well suited for hinge pin applications.

spring anchors, spring control pins.



type 6

Same as Type Two, but with annular grooves on ungrooved end for spring anchor or retaining ring. Type Six is for through holes; Type Seven for blind holes. In addition, annular grooves may be machined to your specification — for use with retainer rings, for example. See catalog for standards.



type 7

SEE OUR CATALOG IN SWEET'S

It's all there, every detail sharp and clear, in RECORDAK precision 35mm microfilm images

There's more to these RECORDAK pictures than meets the eye!

RECORDAK precision 35mm microfilm images *more than meet DOD requirements*—give a minimum of 120 lines per mm resolution at 30-to-1 reduction ratio.

Look closely at some RECORDAK microfilm images in a film reader. See how every detail is sharp and clear . . . how the backgrounds are remarkably uniform, even though the pictures you're looking at were made from drawings and prints of every type and age.

How do these RECORDAK pictures come out so well?

First, the negatives are made on RECORDAK Micro-File Film with RECORDAK Precision Microfilming equipment. Carefully controlled exposure techniques assure uniform backgrounds and contrast. The exposed film then is developed, according to the most up-to-date scientific standards.

Your staff can easily be trained in the use of RECORDAK Micro-File equipment especially calibrated to produce images which meet DOD requirements.

This is important, for your success with an automated engineering drawing program depends *mainly* on the quality of the pictures you use, and on the quality of the prints you can make from them.

Free booklet goes into more details on precision microfilming available through Recordak or a Microfilming Dealer of Recordak.

MAIL COUPON TODAY

RECORDAK CORPORATION
415 Madison Ave., New York 17, N.Y. DD-3

Send booklet describing RECORDAK Engineering Drawing System and name of nearest Microfilming Dealer of Recordak.

Name_____

Company_____ Position_____

Address_____

City_____ Zone____ State_____

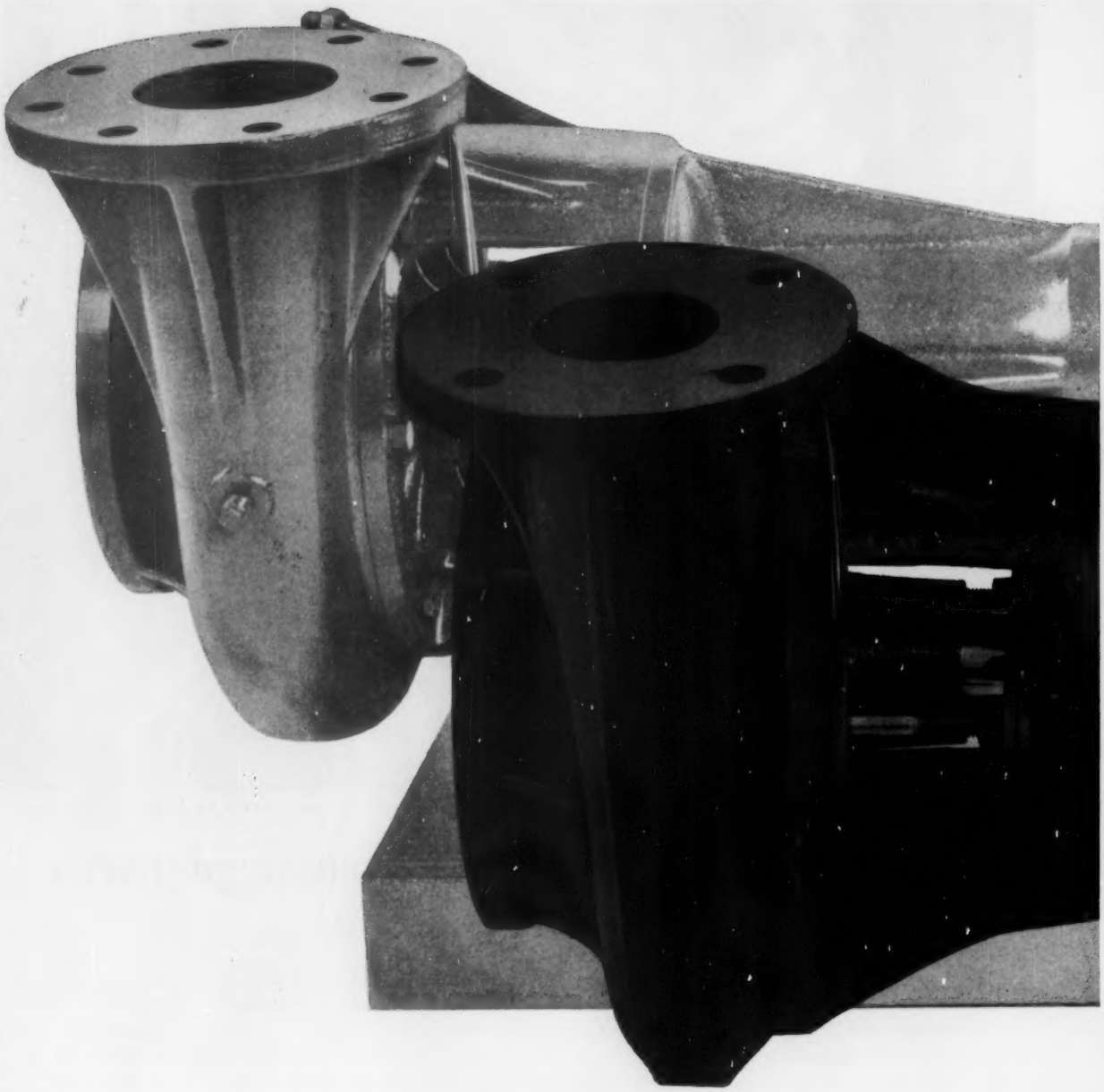
RECORDAK®

(Subsidiary of Eastman Kodak Company)

originator of modern microfilming
—now in its 33rd year

IN CANADA contact Recordak of Canada Ltd., Toronto

Circle 493 on Page 19



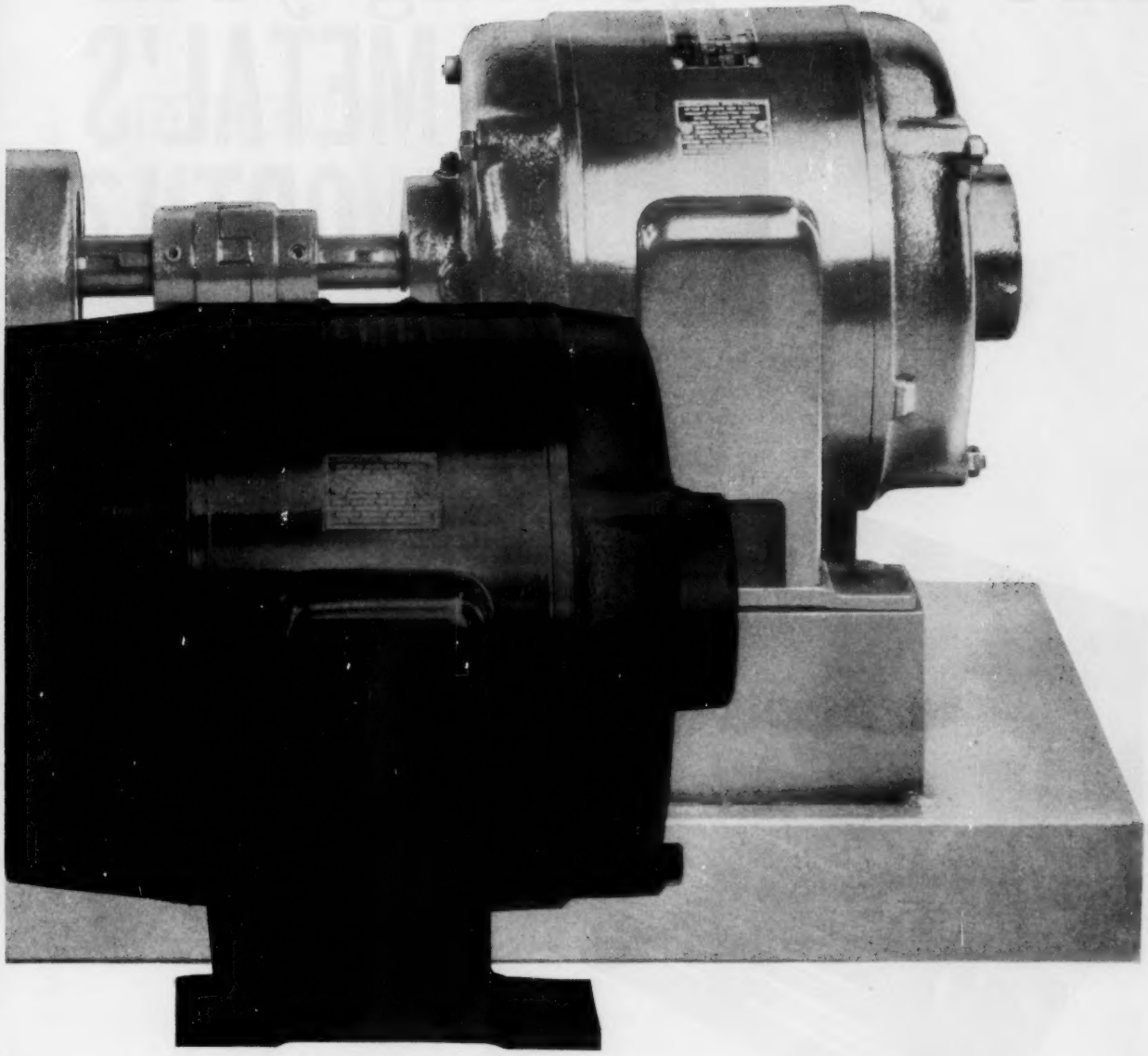
Century close-coupled pump motors

Century close-coupled pump motors make real design sense, especially today when mounting space costs money. The overall length of the pump and motor assembly is considerably shortened—almost 25% in the pumps shown here.

This close-coupled mounting also eliminates the intermediate coupling and bearing. Alignment of pump and motor ceases to be a problem. Maintenance is simplified because there is less to maintain!

Both units shown here are Century 5 horsepower, squirrel cage, open frame construction motors. Both motors are 208-220/440 volts, 3470 RPM (at 60 cycles)

This standard pump construction measures 33⅞" long from bedplate base to the end of the



make this difference . . . and more

pump. The close-coupled pump unit measures 25½" long. This is a difference of 8⅜" in overall length—a space saving of almost 25% in these two comparable horsepower constructions.

The Century close-coupled pump motor is not a "special." Neither is its price. You can order it directly from Century stock. Your Century representative (he's a full-time motor specialist) or distributor can give you full details on close-coupled pump motors—including prices and delivery time. Contact him right away, and write for Bulletin 1455 to:

CENTURY ELECTRIC COMPANY
St. Louis 3, Missouri *Offices and Stock Points in Principal Cities*

Century
60-4

are you getting your METAL'S WORTH?

COST SAVING: 60%

That's how much Jamieson Laboratories estimate they save by die casting this blower housing from Zamak instead of stamping from steel. Only with a zinc die casting can they get the rugged ***thin-wall*** construction they need—***tough enough*** to take the shocks and vibration encountered in use, yet with thin-wall sections ***ductile enough*** to take extensive blanking and forming operations after casting. Neither competitive die casting material—aluminum or magnesium—nor the leading injection molded plastics, can meet these demands.

"The design is highly functional and extremely low cost compared to other methods of manufacture," says Jamieson. Can you say that of your own choice of fabrication? Are you getting your metal's worth? Remember—Zamak gives you more for less.

BLOWER HOUSING, WHITECAP AIR-CONDITIONED HELMET
AWARD OF MERIT
The New Jersey Zinc Company's "Zinc Die Casting of The Year" contest
Die Cast by Westland Die Casting Company

HORSE HEAD® SPECIAL ZINC AND HORSE HEAD ZAMAK ARE PRODUCED BY

THE NEW JERSEY ZINC COMPANY
160 FRONT STREET • NEW YORK 38, N. Y.
DEVELOPERS OF THE ONLY STANDARD ZINC DIE CASTING ALLOYS IN USE TODAY

HORSE HEAD PRODUCTS

MACHINE DESIGN

March 16, 1961

E & R

RESEARCH and Development, R & D for short, is a catchword rather than a well-defined, integrated function. Broadly, it connotes those areas of activity that lead to new products, or weapons. But it seems to stop short of the all-important stage of design for production—the form in which a product reaches the hands of customers.

We like Karger and Murdick's more comprehensive phrase Engineering and Research (E & R, if you prefer initials), which they discuss in this issue. The two functions are distinct, and also complete.

Engineering, which includes development and design, embraces those activities which have a predictable result. Research has no predictable outcome, though it usually has goals. Together, research and engineering embrace the whole spectrum of new product activity from ideas to hardware.

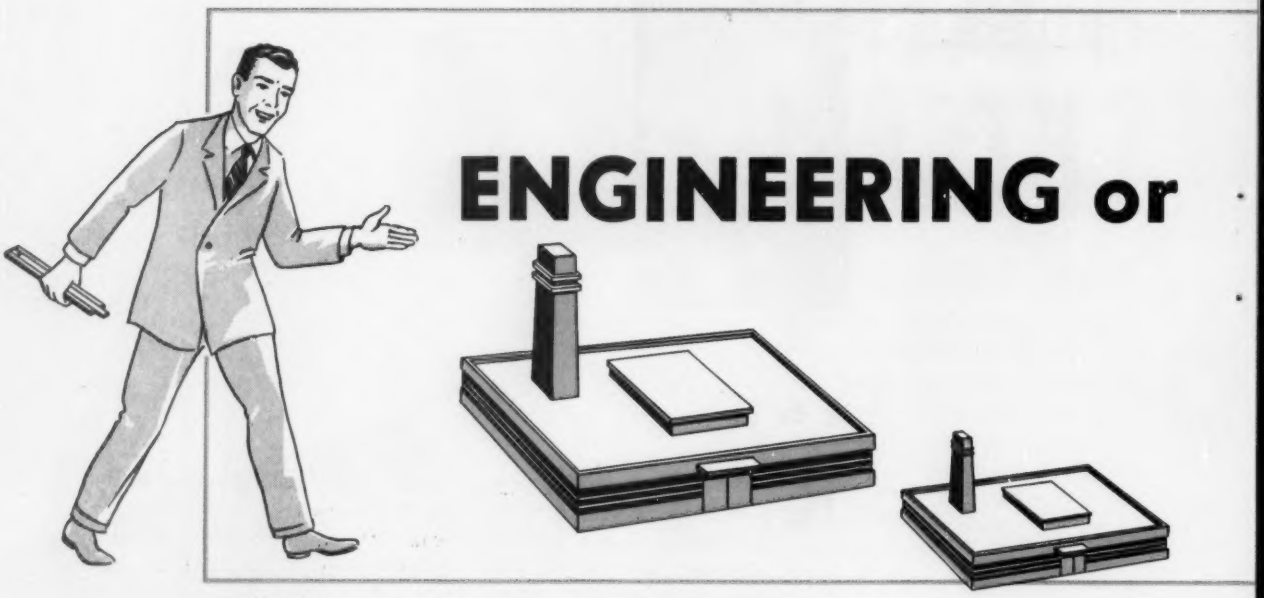
Basic research and applied research differ from each other mainly in the sharpness with which the goals are defined. Both represent quests for new information—exploring the unknown — research to *know*. An illegitimate cousin, research to *show*, is of interest only in the promotion of sales: "Research proves . . . ."

Engineering has goals, too, but with an important difference—the results are known in advance, or should be. Engineering implies a well-managed plan, a design, to guide the course of a project to a specified result.

One prominent machine manufacturer is fond of saying his products are "better—by design." The concept of intention and purpose is the key to this function, whether we call it engineering, design engineering, or simply design.

Colin Carmichael

EDITOR



ENGINEERING or

DELMAR W. KARGER and ROBERT G. MURDICK
Dept. of Management Engineering
Rensselaer Polytechnic Institute
Troy, N. Y.

Just what part does engineering and research play in industry? The answer is suggested by the staggering amount of money being spent on E & R and the emphasis both engineering and research have been receiving in the last few years from larger companies.

But how about the medium-size company? And the small company? Should they place more emphasis on engineering, or on research? And how do they go about organizing a program?

This article gives many of the answers. It also provides a working background for any engineer who aspires to management.

IN RECENT years, industry has become increasingly dependent on technological innovation for survival and growth. According to a National Science Foundation survey, industrial engineering and research expenditures in 1960 went over the $10 billion mark. The relationship between expenditures on E & R and returns on investments is outlined in Table 1.

Engineering and research permeate every activity of a company and are pertinent to every major policy and decision made. Yet while the rise of engineers and scientists to management positions is increasing, many large firms are still managed by men who rose through the marketing, manufacturing, or financial functions. E & R management is therefore bearing a greater responsibility than ever for promoting such major objectives as:

1. Insuring that the company operates in areas of rapidly advancing technologies.
2. Assuring maximum usage of the company's resources.
3. Exploiting both active and potential markets.
4. Providing diversification of the company's products.
5. Insuring an increasing profit potential.

E & R management has broader responsibilities

RESEARCH

. . . which should be emphasized in a company's over-all planning?

than company activities, however. Political and social movements, fed by the fuel of technology, are creating an irresistible rush into the future. No longer is management concerned merely with competition at the level of the firm, but with response to pressures of newly developing countries and to the challenge of Russian growth.

How Important Is Research?

Average distribution of the E & R expenditures of about 200 companies is shown is Fig. 1. Since many companies do no basic research, in many cases E & R is concerned solely with the application of existing knowledge to improvement of a present product or process, the application of existing knowledge to the creation of new products, or the planned search for new knowledge for a specific application.

Engineering and research interact over a wide range of activities and through varying degrees of complexity, as shown in Fig. 2. But in many cases, management's failure to recognize that either engineering or research must dominate causes confusion, wasted effort, internal conflict, and excessive cost

Table 1—Research Expenditures and Rate of Return in the United States, by Industries*

Industry	Research Expenditure As Per Cent of Sales†	Return on Net Worth§
Aircraft and parts	17.6	17.8
Electrical equipment	5.3	12.6
Professional, scientific, and controlling instruments	4.8	12.0
Chemical and allied products	2.3	13.2
Motor vehicles and other transportation	2.3	12.5
Machinery (except electrical)	2.0	10.7
All manufacturing	1.8	10.9
Rubber	1.3	11.2
Petroleum products	0.80	12.4
Stone, clay, and glass	0.73	12.3
Fabricated metal products	0.57	9.3
Paper and allied products	0.39	8.9
Primary metal	0.33	10.6
Lumber and furniture	0.16	0.6
Food and kindred products	0.15	8.6
Textile mill and apparel	0.11	4.8

**Trends in Industrial Research and Development,* Yale Brozen. †1956. §1957.

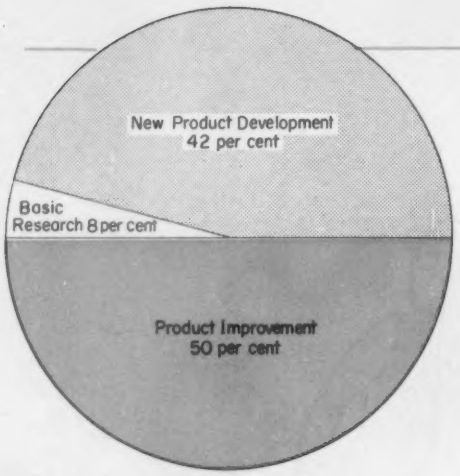


Fig. 1—Average distribution of company expenditures for engineering and research.

of E & R. The question is, which function shall dominate?

In general, engineering and research groups should be separated. Neither one should be an adjunct of the other, although the heads of the separate groups may report to the same company officer. In some cases, the research group may consist of a group of scientists, identified as a "technology" group, and on the same level as engineering.

Some instances in which research dominates engineering are in the drug, chemical, or metallurgy fields, where applied research is most vital, and engineering provides a service or production-development function.

Here, product development passes from applied research to engineering to production. As research begins to define a theory and determine its nature, engineering becomes involved in possible practical applications. In some cases, engineering is simply called upon for production design. Then, while research begins to explore related avenues that may have been opened, engineering evaluates previous information passed on by the research group to determine its possibilities for existing or new products. Eventually engineering accepts its full responsibility for applying the idea. By this time research has defined and classified the theory and has gone on to others.

This is, of course, an oversimplification, but it does illustrate the shift in responsibilities. It is a function of management to control this shift from research to engineering so that it occurs smoothly and effectively. It is a well-recognized management precept that duplication of activities must be eliminated and responsibilities clearly defined if an organization is to function with maximum effectiveness.

In companies that manufacture machinery, transportation equipment, household appliances, etc., the prime responsibility for product development must rest in engineering. Applied research becomes a service—although a very important one, for an unexpected, highly specialized problem can hold up engineering development if not solved immediately. Applied research can also help in preventing such holdups by conducting research on problems encountered while evaluating possible alternative products. The research group may also follow new developments in related fields, culling out the most promising and referring them to engineering.

In engineering-dominated organizations, misunderstanding of the research function accounts for large losses in the research budget. Management sometimes fails to realize that research is not product

6	Basic Research			
5	Applied Research	Conceptual Design	Advanced Development	
4	Applied Research	Engineering Evaluation	Advanced Development	Design Engineering
3		Systems Design	Advanced Development	Design Engineering
2		Systems Design		Design Engineering
1	Production Design			

Fig. 2—Degree of complexity of various engineering and research programs undertaken by a company. In general, the size of the company, as well as its area of activity, dictate which phases it decides to pursue.

development, and new products are therefore not an immediate result. So research departments are often sidetracked in specific product-development assignments or are brought in only in engineering crises.

While such sidetracking is often the result of management choice, it also occurs because engineering is negligent and fails to accept its proper responsibilities for product development.

Research should point the way to new products, new processes, and lower costs, but it is the engineer's job to develop the most promising of the research group's findings. Thus, the research group is free for further exploratory studies.

There are many ways in which the research function may be organized, depending upon the type of company and its emphasis on engineering. Research may be organized along lines parallel to the engineering organization; according to technical fields such as physics, metallurgy, etc.; or into interdisciplinary product-development teams. Fig. 3 gives an example of one type of engineering and research organization.

What Is Engineering's Responsibility?

Engineering may be considered primarily as creating and processing information of combined technological and economic nature. Processing information consists of computing, converting, transporting, reproducing, sorting, storing and retrieving. These basic elements can, of course, be combined in various ways.

More than 50 years ago one of the founders of industrial engineering, Dr. Frederick W. Taylor, in a commencement address at Purdue University, stated that an engineer was a man who could produce the same part for one dollar that anyone else could produce for two dollars. Management tends to agree. They have also come to realize that the engineer can be useful in many other ways in today's modern and complex business scene. He is a much sought-after specialist, and his creations are used by everyone in civilized society. For this reason, it is necessary for him to play a key role in new product development.

Since in many cases engineers carry research results right through the development of a new product, they should logically be consulted in making any final decisions regarding new product-development programs. Competition not only demands varied, high-quality, reliable products, but also minimum cost. Both of these aspects—development and cost—are a primary responsibility of engineering. They emphasize the importance of engineering to the attainment of over-all company objectives.

Engineering's primary function or responsibility is that of creating and designing a product which can be produced competitively, and which will perform satisfactorily in the hands of the customer. However, satisfactory performance is a broad term that must also include service maintenance.

Engineering may be organized along functional lines, Fig. 4, according to various fields, along product lines, or by projects. In addition, some groupings are a mixture of functional and project organization.

Effect of Company Size and Type

Size of a company, as well as its product, affects relative emphasis placed on engineering and research.

Small Companies: Often, small manufacturers try

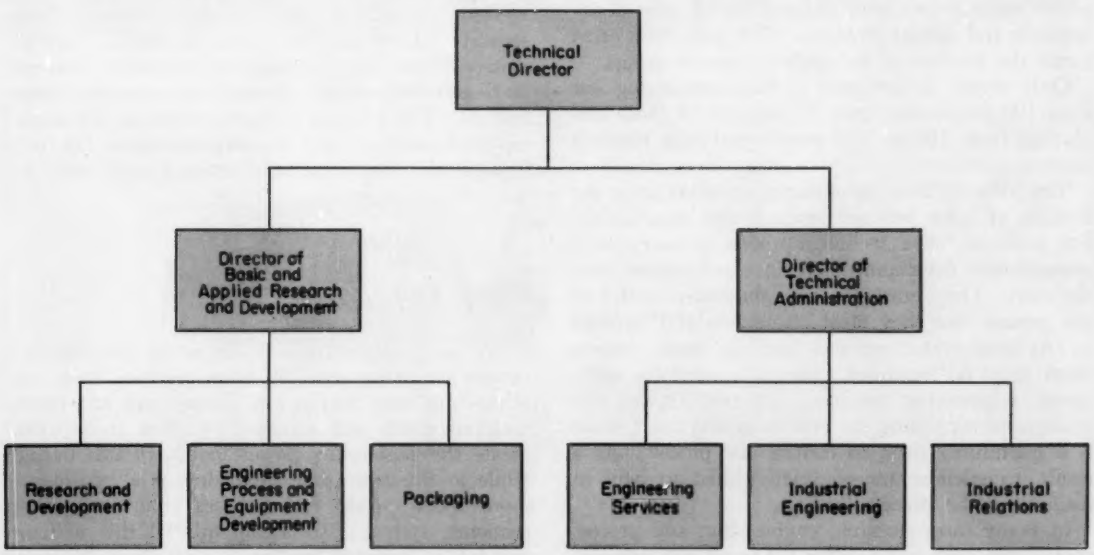


Fig. 3—Organization chart for E & R function in developing a line of household products. Organization structures vary with the size of the company and the degree of importance attached to engineering and research.

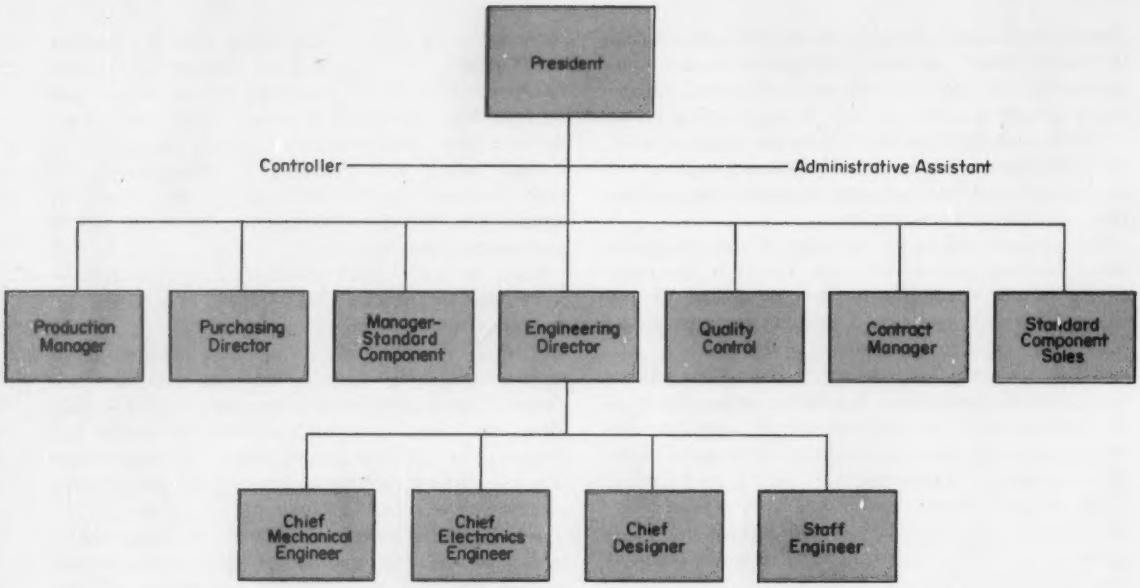


Fig. 4—Typical company organization chart.

to economize by hiring mechanics or technicians to do an engineer's job. Such use of technicians or mechanics is usually false economy. Development of all but the very simplest modern products requires a broad variety of engineering skills.

Usually, a small company combines its engineering activities under one department head. As the company grows, the design engineering group should be separated as soon as possible to achieve full responsibility for product development.

At some point in their growth, a company may have to hire a high-level research consultant to advise management and engineering on new developments and special problems. This consultant often forms the nucleus of an applied research group.

Only about 10 per cent of firms employing less than 100 people and only 30 per cent of those employing from 100 to 500 people maintain research organizations.

The industry involved also has an effect upon the division of labor between research and engineering. For example, in a technical-process industry both research and development are involved almost from the start. They must not only maintain control of the process, but they must also refine and improve it. As production increases and the small process plant must be expanded, there is a need for additional engineering services. In addition to the problem of expanding the process facility itself, there is a continuing need to control the process. As a result, technicians are eventually hired to help in controlling the process facility.

In many cases research, engineering, and process control continue to be under the same manager until the operation becomes too large for one man to handle. Eventually, research activities are given status as a separate organization responsible for product development.

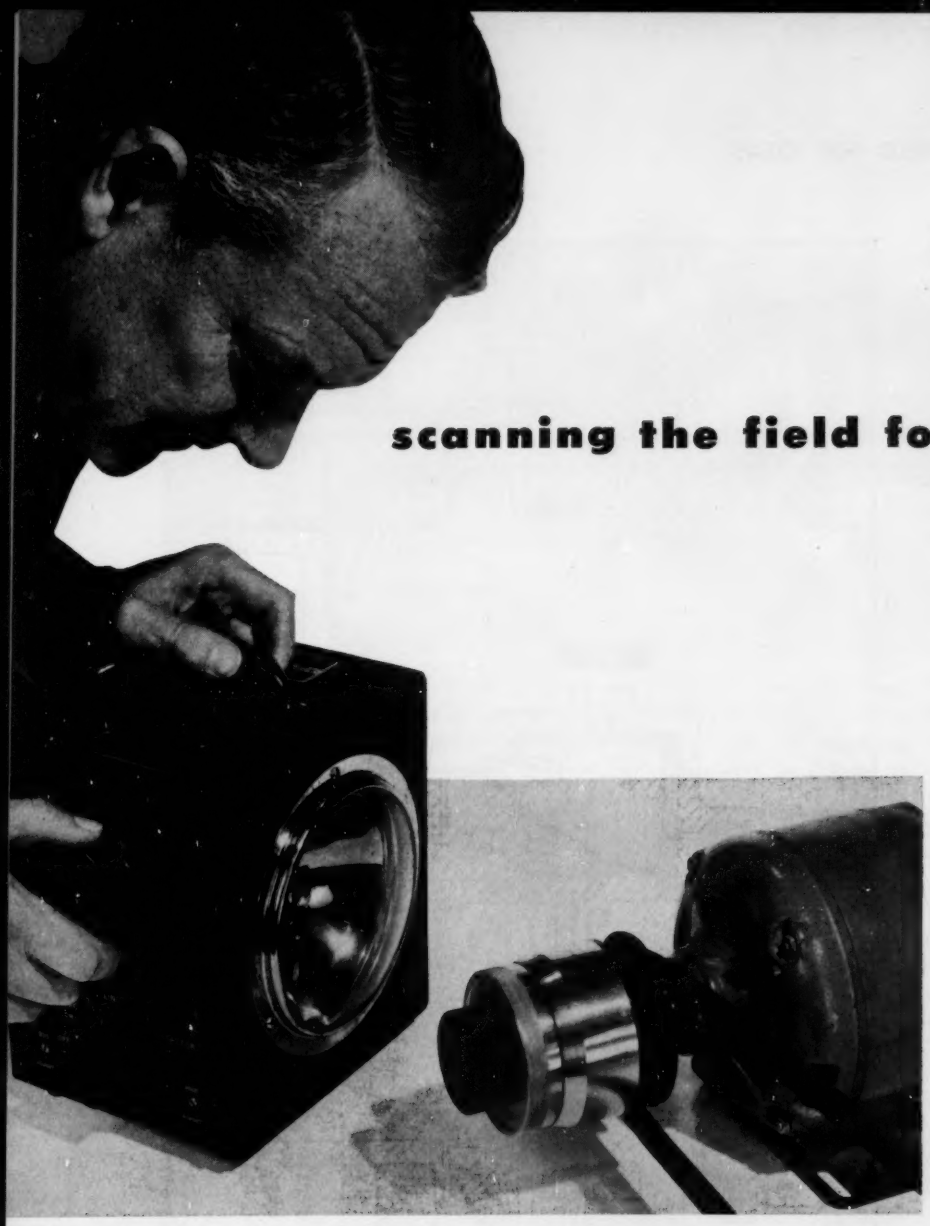
Medium-Size and Large Companies: In medium and large-size companies, the research-development and design-engineering groups are much larger than in small companies, and may be separated by a considerable physical distance. In the over-all picture, co-ordination of E & R is critical. Both research and engineering exist to contribute to the total product program and the responsibility of each must be specified with respect to this program.

Today, most of the medium-sized companies have separate laboratories and research staffs. Approximately 85 per cent of companies employing between 2000 and 5000 employees maintain research organizations. The greatest difference between the medium-sized company and the large company lies, perhaps, in the amount of basic research each conducts.

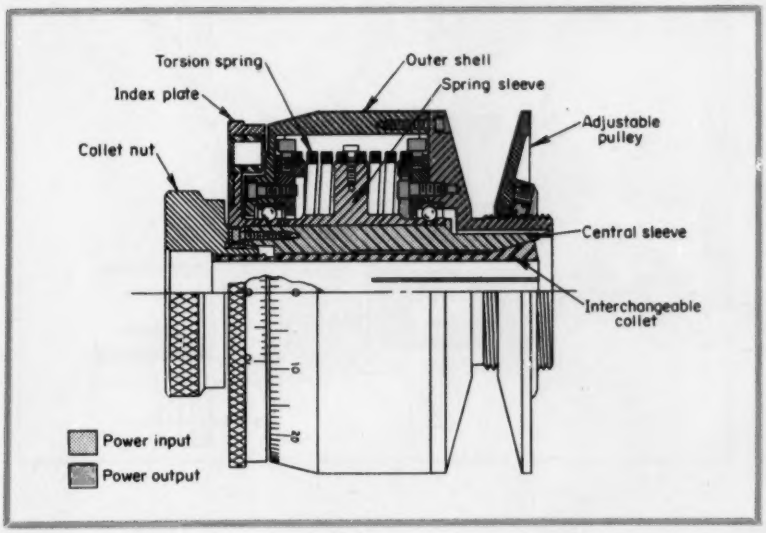
They say . . .

We must demonstrate to the world that the free enterprise system can be more creative than any other—not only that it can create more and better material goods and services, but that it also can create the purchasing power to absorb this output while at the same time producing as a by-product more social goods and services than any other economic system. To accomplish all this without any loss in personal freedom is a challenge to every free individual.—John F. Gordon, *President, General Motors Corp.*

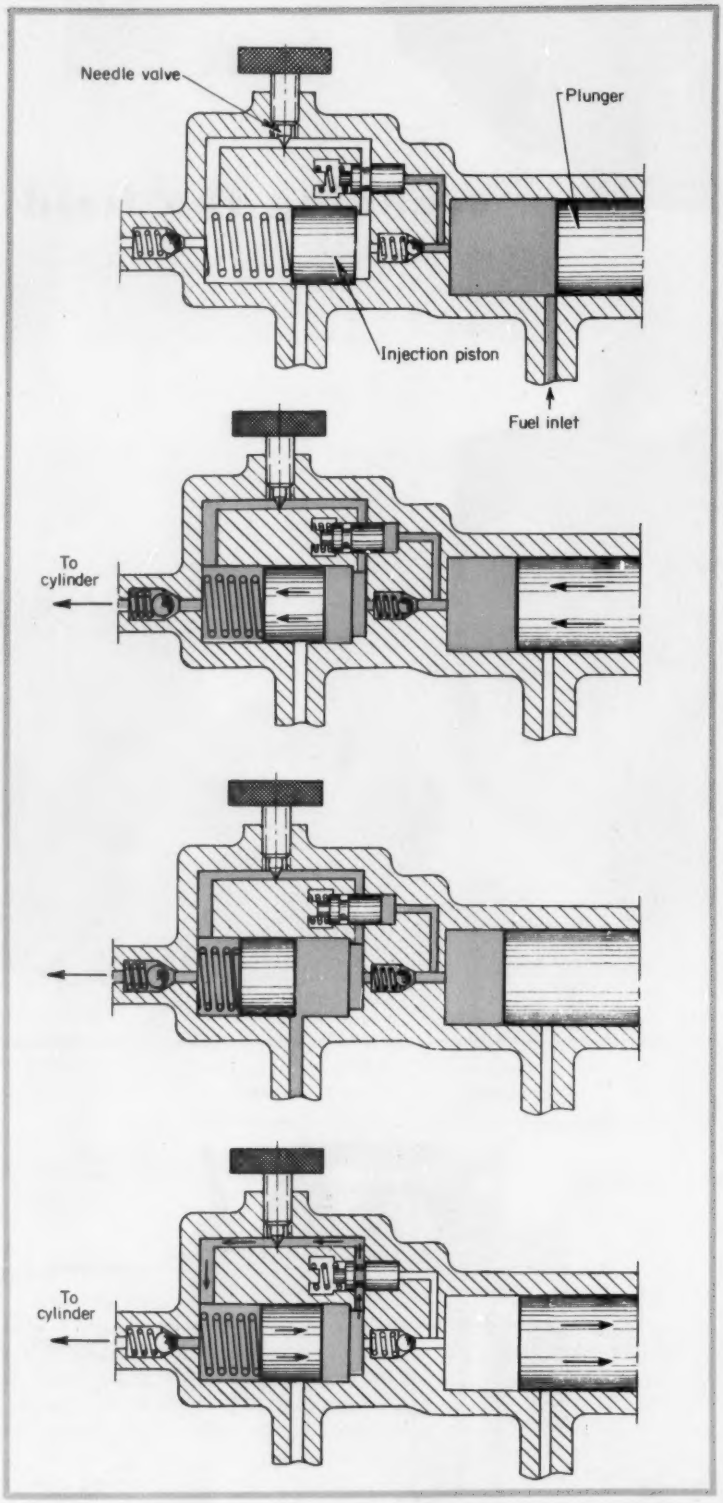
scanning the field for *ideas*

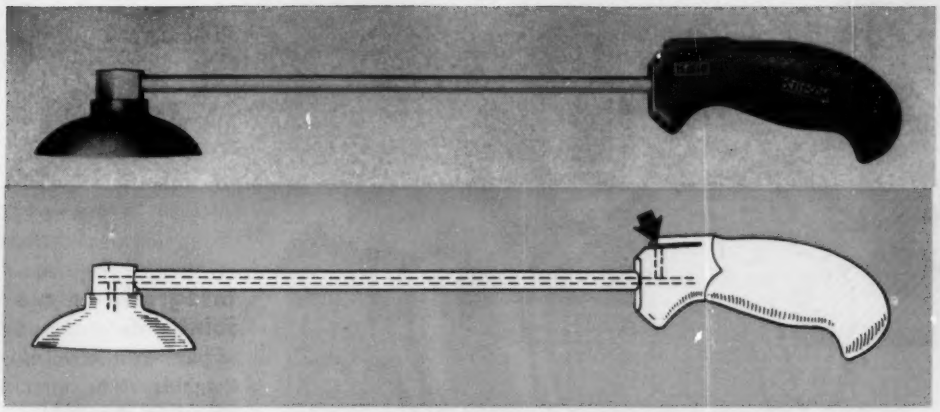


Stroboscope-illuminated scale indicates torque transmitted through a torsion-spring dynamometer. Under running load, one scale rotates relative to the other. Thus, torque can be determined from the scale reading and speed from the stroboscope reading so that power can be computed. Principle employed in a dynamometer by Micro Pump Corp., Danville, Calif.



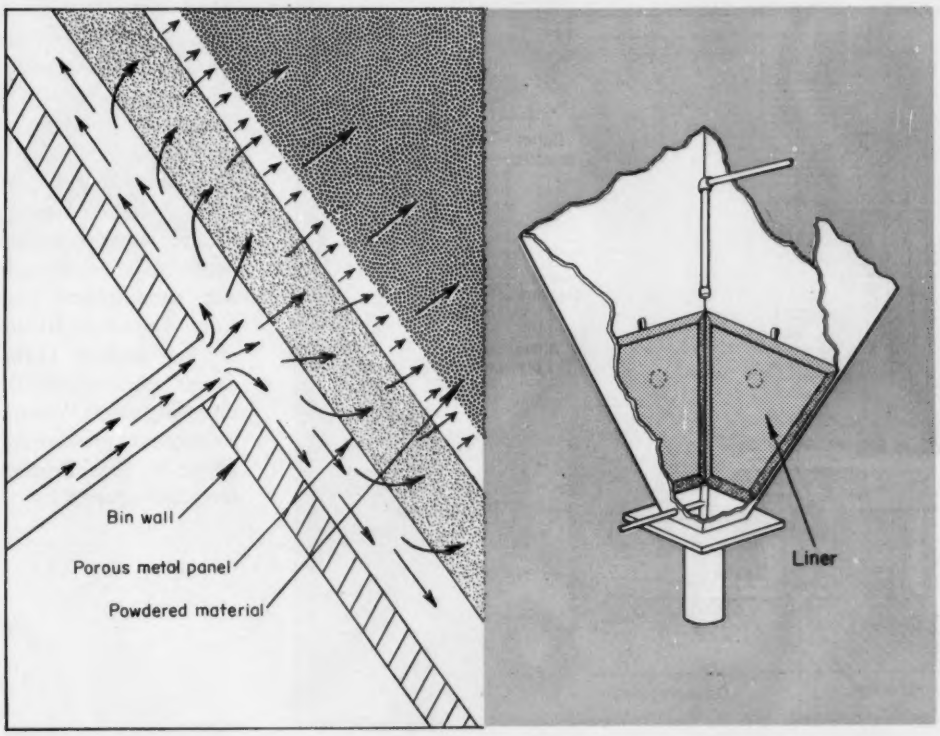
Liquid stop limits return stroke of injector piston in a diesel-engine governor to control engine speed. The rate of the return stroke is controlled by an adjustable needle valve. Time permitted for return stroke depends upon speed of engine-driven plunger. Thus, for a given setting of the needle valve, any increase in engine speed reduces the amount of fuel injected. Conversely, a decrease in engine speed increases the fuel flow. Liquid stop principle employed in diesel-engine governor developed by Precision Mecanique Labinal, Paris, France.

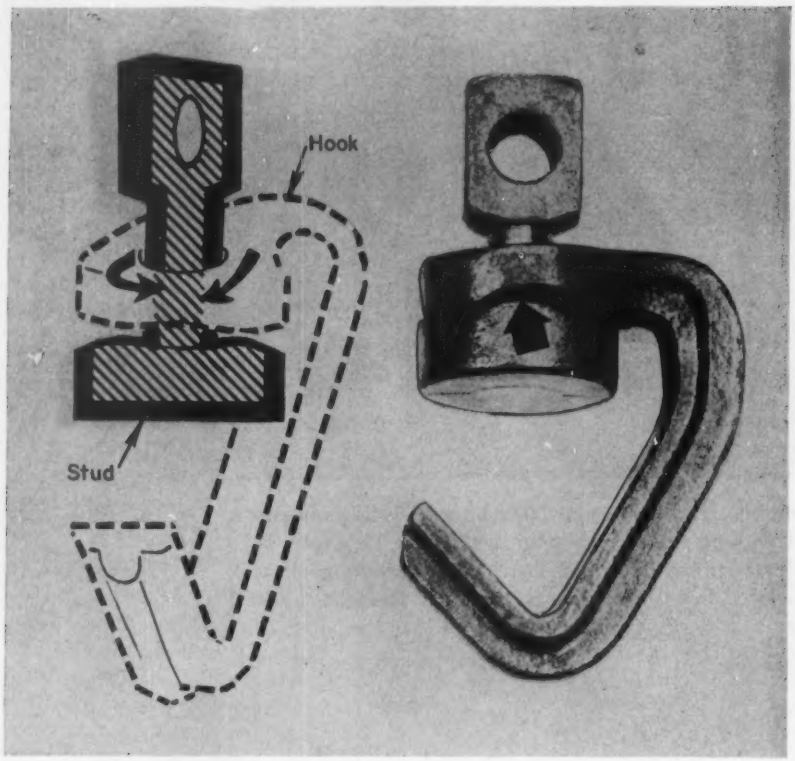




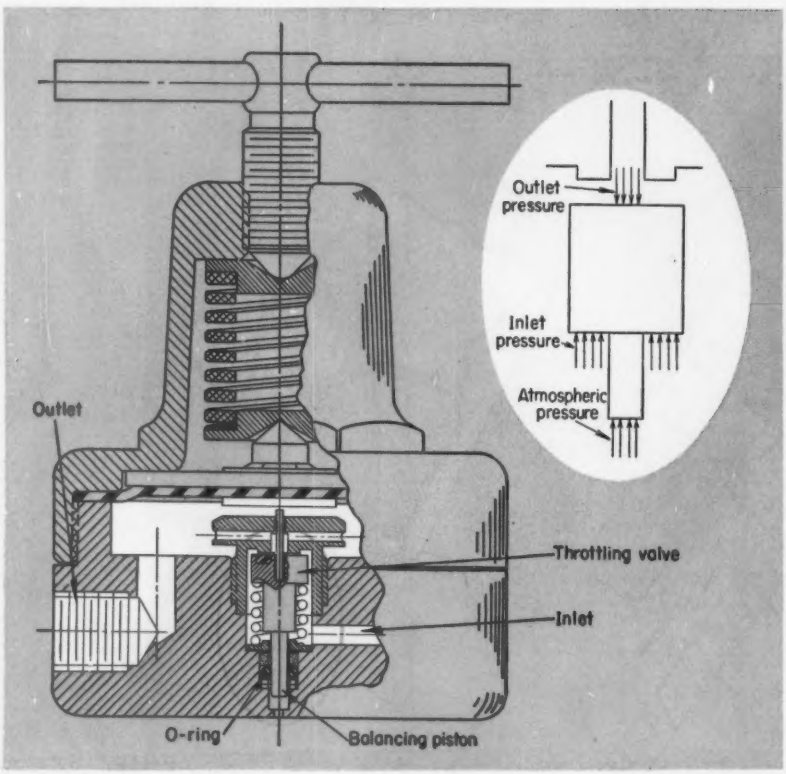
Flexible-flap valve controls air access to a vacuum lifter. The vacuum cup is struck against a flat surface, while the flap is held against the air inlet. To release the vacuum cup, the thumb-actuated flap is released, permitting air to enter the cup. Principle employed in lifter by Stilson Tool Inc., Roseville, Mich.

Fluidizing gas, admitted through porous-metal panels, provides low-friction support for powdered materials. One use is to provide easy material flow and prevent bridging and caking in storage bin. Fluidizing principle employed in bin-liner panels by Micro Metallic Div. of Pall Corp., Glen Cove, N. Y.



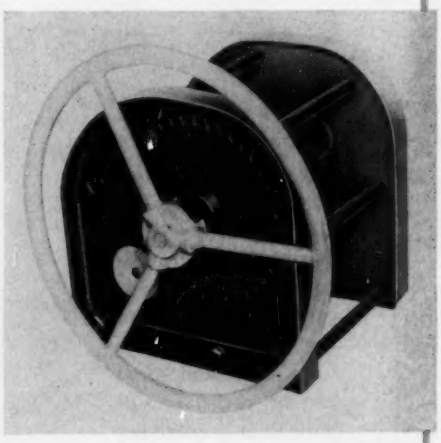


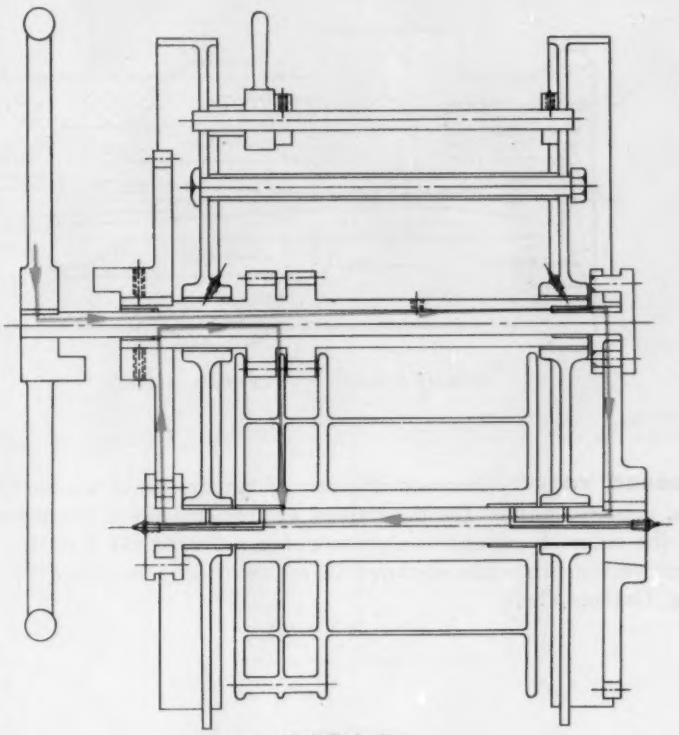
Integrally cast joint reduces number of parts in a swivel hook assembly. The stud is placed in the mold prepared for the hook, and protected from the molten metal by sand. When the hook is poured, the molten metal encircles the stud. Principle employed in hook cast by Cadillac Malleable Iron Co., Cadillac, Mich.



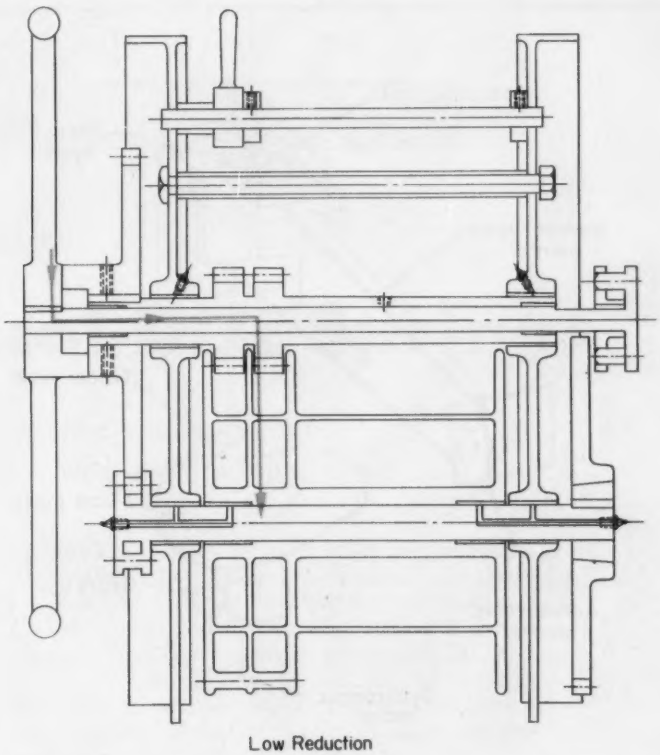
Balanced throttling valve reduces effect of variation of inlet pressure in a single-stage throttling valve. The piston, an extension of the throttling valve, permits a portion of the area normally exposed to the variable supply pressure to be exposed to constant atmospheric pressure. The slight friction of the sealing O-ring damps vibrations of the throttling valve. Principle employed in pressure regulator by Kim Products Inc., Lexington, Ky.

Alternate power paths provide quick-change gear ratios in a hand-operated winch. When the handwheel is pulled axially toward the operator, three gear sets give high reduction ratio. When handwheel is pushed away from operator, drive through one gear set provides low ratio. Principle employed in hand-operated winch by Western Gear Corp., Houston, Tex.

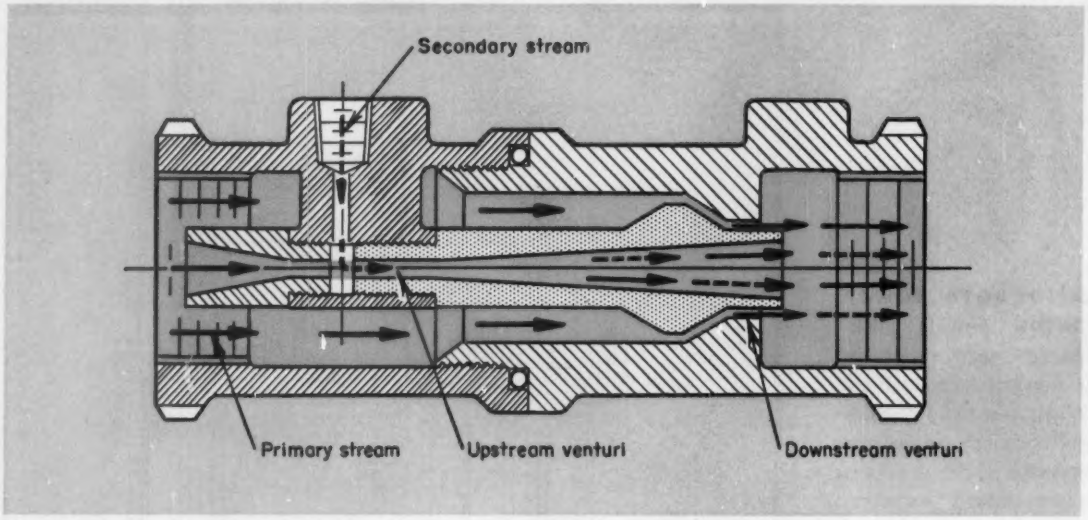




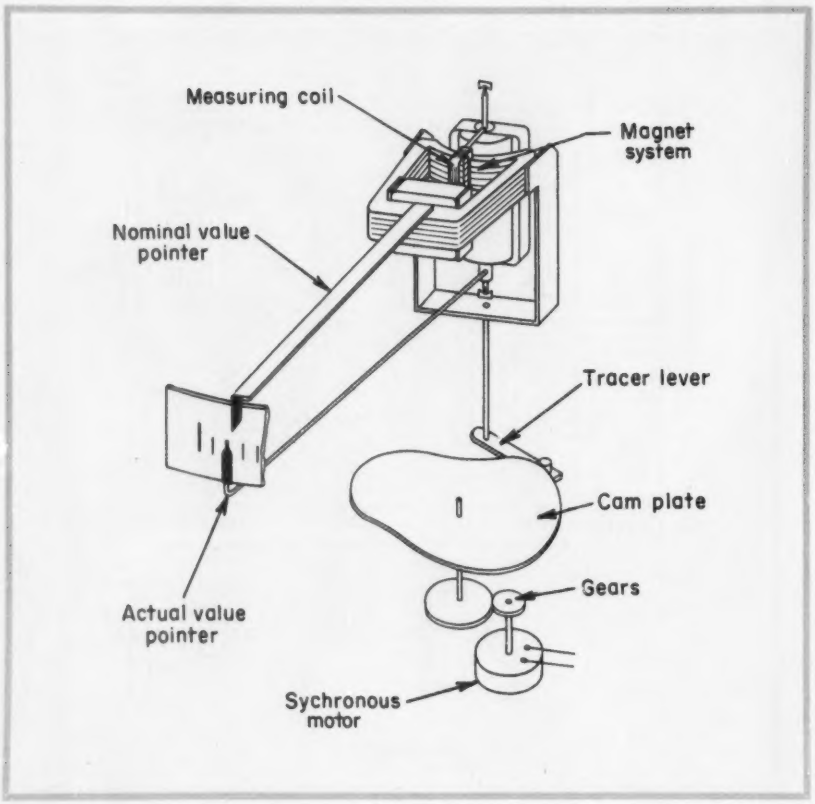
High Reduction



Low Reduction



Compound venturi increases efficiency of introduction of a secondary fluid into the primary stream. The downstream venturi produces a low-pressure area around the outlet of the upstream venturi, thus increasing the flow through the upstream venturi. Principle employed in an air charger developed by Nielsen Mfg. Co., Oakland, Calif.



Cam - controlled magnet provides a reference input into a process regulator. The error signal produced depends upon relative position of the cam-controlled magnet and the measuring coil. Cam shape and speed can be varied to suit individual operating requirements. Principle employed in regulator manufactured by Allgemeine - Elektricitaets - Gesellschaft, Berlin, Germany.

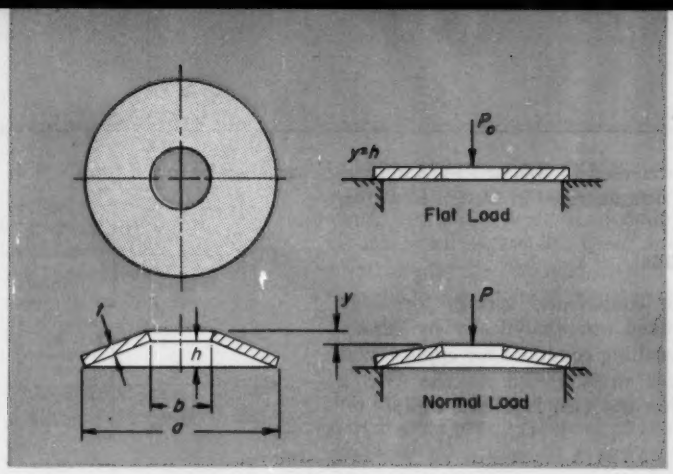


Fig. 1 — Conical-disc spring showing representative nomenclature.

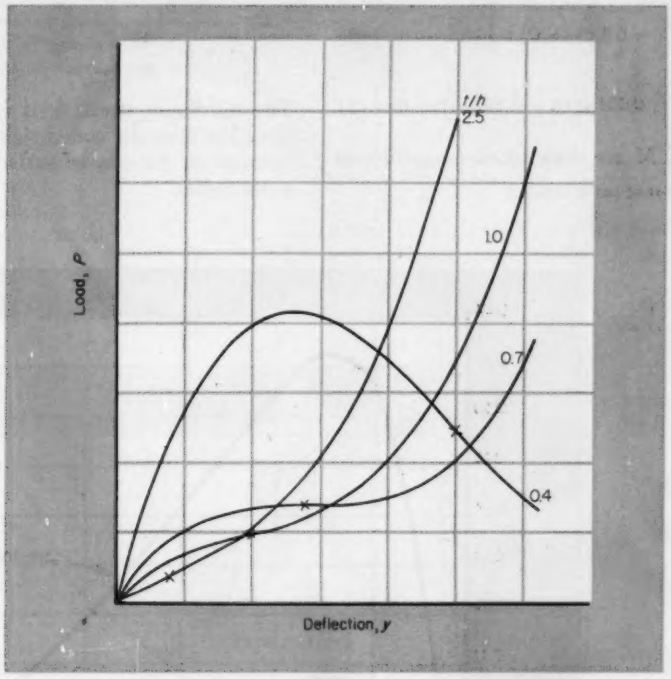


Fig. 2 — Load-deflection characteristics of conical-disc springs. The points indicate condition $y=b$.

Designing

Conical-Disc Springs

to provide specific load-deflection characteristics with a minimum space

ARTHUR D. BRICKMAN

Dept. of Mechanical Engineering
The Pennsylvania State University
University Park, Pa.

CONICAL discs are widely used as compression (Belleville) springs to support large loads where space in the direction of loading is limited. Conical-disc springs, Fig. 1, have a unique feature. Their stiffness (change of load per unit change of deflection) varies over the full range of deflection. In addition, load-deflection characteristics can be readily altered by simply changing the proportions of the disc, Fig. 2.

Details of a simplified approach to conical-disc

spring design are presented in this article. A typical problem solution is demonstrated in *Design Example*.

Design Equations

The behavior of conical-disc springs for large deflections was worked out analytically by Almen and Laszlo.[1] The resulting equations for applied load P, maximum induced stress S, and stiffness K as a function of deflection are (see Nomenclature):

$$P = \frac{4E'y}{Ma^2}\left[(h - 0.5y)(h - y)t + t^3\right] \quad (1)$$

$$S = \frac{4E'y}{Ma^2}\left[C_1(h - 0.5y) + C_2 t\right] \quad (2)$$

$$K = \frac{4E'}{Ma^2}\left[(h - 0.634y)(h - 2.366y)t + t^3\right] \quad (3)$$

where C_1, C_2, and M are dimensionless coefficients and can be found from

$$C_1 = \frac{6}{\pi \ln \frac{a}{b}}\left[\frac{\frac{a}{b} - 1}{\ln \frac{a}{b}} - 1\right] \quad (4)$$

$$C_2 = \frac{6}{\pi \ln \frac{a}{b}}\left[\frac{\frac{a}{b} - 1}{2}\right] \quad (5)$$

$$M = \frac{6}{\pi \ln \frac{a}{b}}\left[\frac{\frac{a}{b} - 1}{\frac{a}{b}}\right]^2 \quad (6)$$

The maximum stress, S, is compressive. For deflections less than the cone height ($y < h$), this stress is induced on the convex surface of the washer at the inner radius.

[1]References are tabulated at end of article.

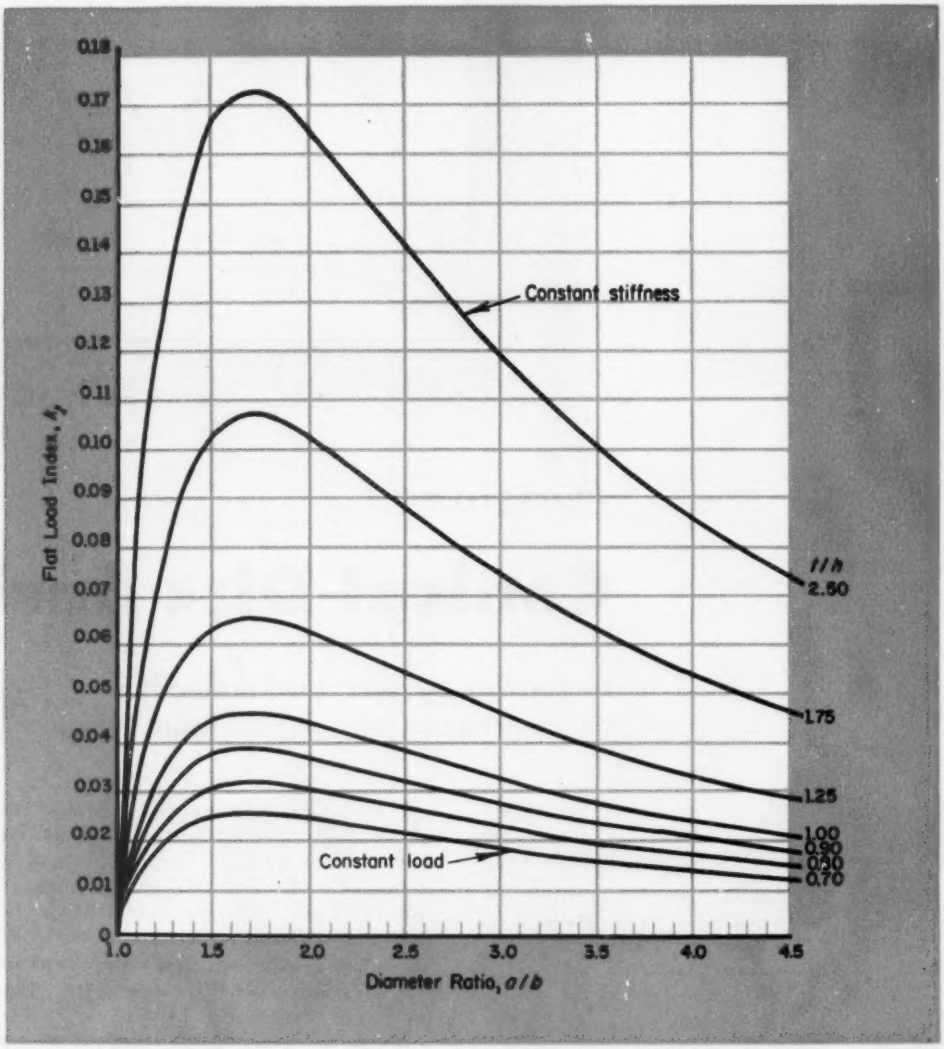


Fig. 3—Chart for finding flat load index, k_1.

Nomenclature

a = Outside diameter of conical-disc spring, in.
b = Inside diameter of conical-disc spring, in.
C_1 = Dimensionless coefficient (Equation 4)
C_2 = Dimensionless coefficient (Equation 5)
E = Modulus of elasticity of spring material, psi
E' = "Plate" modulus of spring material, psi
$= E/(1 - \nu^2)$
h = Cone height, in.
K = Stiffness of conical-disc spring at deflection y, lb/in.
K_o = Stiffness of conical-disc spring at flat height, lb/in.
k_l = Flat load index
k_s = Flat stiffness index
L = Free height of spring assembly, in.
M = Dimensionless coefficient (Equation 6)
m = Number of parallel spring sets in a series
n = Number of springs in each parallel set
P = Applied load, lb
P_o = Load to deflect spring to flat height, lb
S = Maximum induced stress, psi
S_o = Maximum stress at flat height, psi
t = Stock thickness, in.
y = Deflection from free height, in.
y_o = Total deflection at flat height, in.
ν = Poisson's ratio

These equations are impractical for design work, since for any given spring dimensions the load, stress, and stiffness at the working deflection must be calculated separately. Even though a satisfactory solution may be obtained in this way, it is usually difficult to determine spring proportions that require minimum space, yet satisfy a critical combination of service conditions.

Because many conical washer applications involve deflections that are nearly as great as the cone height, a more convenient approach is to use the "flat" condition of the spring as a design criterion. For this case, $y = h$, and Equations 1, 2, and 3 become

$$P_o = \frac{4E'a^2}{M}\left(\frac{h}{t}\right)\left(\frac{t}{a}\right)^4 \quad (7)$$

$$S_o = \frac{4E'}{M}\left(\frac{h}{t}\right)^2\left(\frac{t}{a}\right)^2\left(\frac{C_1}{2} + C_2\frac{t}{h}\right) \quad (8)$$

$$K_o = \frac{4E'a}{M}\left(\frac{t}{a}\right)^3\left(1 - \frac{h^2}{2t^2}\right) \quad (9)$$

where P_o, S_o, and K_o are the load, maximum stress, and stiffness, respectively, of the flattened spring.

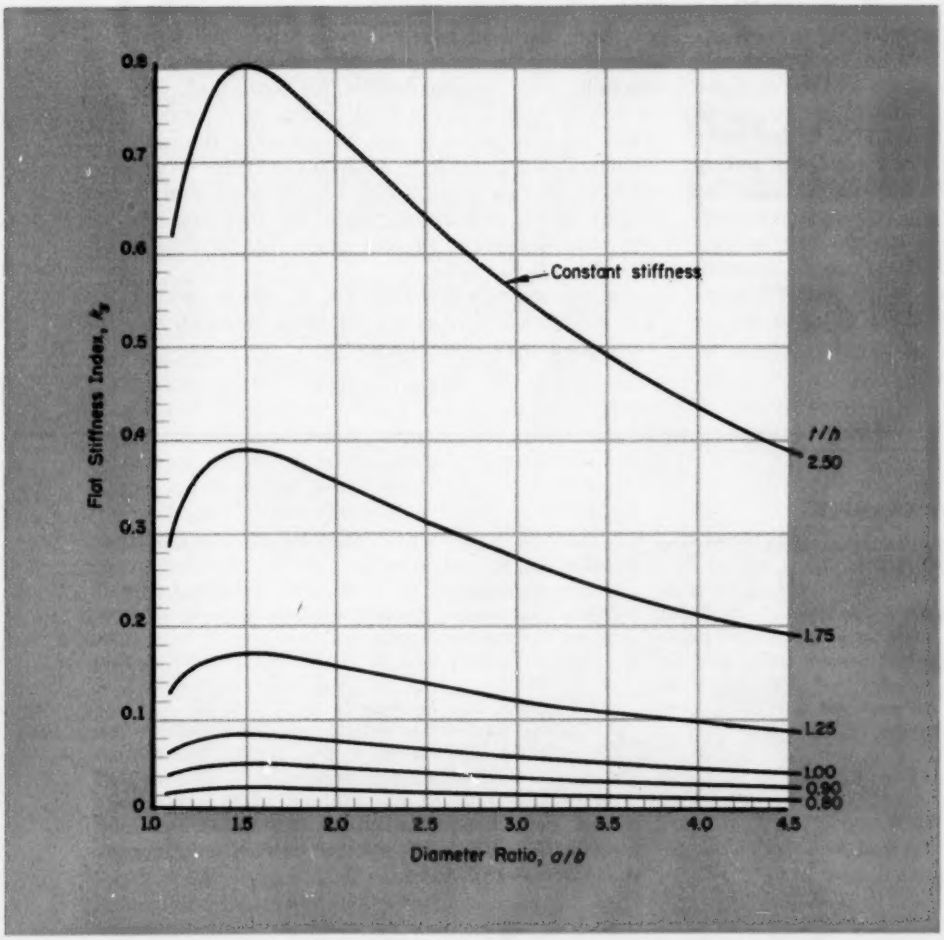


Fig. 4—Chart for finding flat stiffness index, k_s.

A further simplification can be made by eliminating the thickness-to-diameter ratio, t/a, which appears in all three of these equations. Then, the results can be put into dimensionless form as

$$k_l = \frac{P_o E'}{a^2 S_o^2} = \frac{M\left(\frac{t}{h}\right)^3}{\left(C_1 + 2C_2\frac{t}{h}\right)^2} \qquad (10)$$

and

$$k_s = \frac{K_o\sqrt{E'}}{a S_o^{3/2}}$$

$$= \left(\frac{\sqrt{M}}{\sqrt{2}}\right)\frac{\frac{t}{h}\left(2\frac{t^2}{h^2} - 1\right)}{\left(C_1 + 2C_2\frac{t}{h}\right)^{3/2}} \qquad (11)$$

Design Parameters

The "flat load index," k_l, defined by Equation 10 may be interpreted as the allowable load capacity of a flattened conical-disc spring having a given outside diameter a, plate modulus E', and allowable stress S_o. Similarly, the "flat stiffness index," k_s, of Equation 11 gives the corresponding stiffness capacity. It can be seen that both indexes depend only on the thickness-to-height ratio t/h and the diameter ratio a/b, so that Equation 10 and 11 can be plotted as a series of parametric curves, Figs. 3 and 4.

The stiffness characteristics of conical-disc springs depend only on the thickness-to-height ratio, as shown in Fig. 2. As this ratio increases, the load-deflection curve approaches a straight line, so that when $t/h = 2.5$, constant stiffness can be assumed, with little error.[2] A reduction of t/h to 0.707, however, reduces the flat stiffness of the spring to zero, as indicated by Equation 9.

Thus, the design curves of Fig. 3 and 4 cover conical-disc spring proportions ranging from constant-stiffness ($t/h = 2.5$) to constant-load ($t/h = 0.7$) types. It is apparent from the shape of the curves shown in Figs. 3 and 4 that for given values of a, E', and S_o, a diameter ratio of $a/b = 1.5$ to 1.7 will maximize both the load and stiffness capacities of a flattened conical washer regardless of the value of the thickness-to-height ratio, t/h.

The load-index and stiffness-index curves in Fig. 3 and 4 provide a time-saving method of selecting spring assemblies that must operate without material failure at or near the flat condition, and be elastically stable. That is, they must have a positive stiffness for all deflections up to the flat condition. Any trial solution made by use of the curves automatically insures that the springs will not undergo permanent set when flattened, provided that the maximum stress S_o, which appears in both indexes, is a safe design stress.

Multiple-Spring Assemblies

When conical washers are used in multiple arrangements, such as those shown in Fig. 5, the load and stiffness of the assembly are, of course, different from the load and stiffness of each individual element. In the series arrangement (Fig. 5*a*), for example, each element carries the total load, but undergoes only half the total change of deflection. Thus, for a series set of two springs under flat conditions, $P = P_o$ and $K = K_o/2$. Similarly, for a parallel set of two springs, Fig. 5*b*, the total load is shared by the individual springs but they undergo the same deflection, so that under flat conditions $P = 2P_o$ and $K = 2K_o$.

For the more general case, Fig. 5c, where parallel sets of identical springs are combined in series, the corresponding relationships are:

DESIGN EXAMPLE

Problem: Design a conical-disc spring assembly to meet the following conditions: OD $\leqq$ 2 in.; ID $\geqq$ 0.5 in.; P = 3000 lb; $K \leqq$ 20,000 lb/in.; $E' = 33 \times 10^6$ psi. P is the maximum load when the spring is flat and K is the desired stiffness at maximum load. Allowable stress is 250,000 psi.

Solution: To obtain a large load capacity and to limit the number of spring elements, n, select a = 2 in., $t/h = 2.5$ (spring of nearly constant stiffness) and $a/b = 1.7$ corresponding to maximum load index, k_l. Thus $b = 2/1.7 \approx$ 1 3/16 in.

From Fig. 3, $k_l = 0.172$. From Equation 10, P_o= 1300 lb. From Equation 12, $n = P/P_o = 3000/1300 = 2.3$. Since n must be an integer, use $n = 2$. Then, $P_o = 3000/2$ = 1500 lb, and from the flat load index determined previously, S_o = 268,000 psi.

From Fig. 4, $k_s = 0.78$. From Equation 11, with S_o = 268,000 psi, K_o = 37,700 lb/in.

From Equation 13, $m = nK_o/K = 2(37{,}700/20{,}000) = 3.77$. Since m must be an integer, use $m = 4$, which requires that the overall stiffness $K = nK_o/m$ = 19,000 lb/in.

From Equation 7, with P_o = 1500 lb, t = 0.091 in. Thus $h = 0.091/2.5 = 0.036$ in. Then, from Equation 15, L = 0.875 in. and, from Equation 14, y_o = 0.146 in.

The trial solution thus yields a spring stack similar to that shown in Fig. 5c, where OD = 2 in.; ID = 1 3/16 in.; cone height, h = 0.036 in., stock thickness, t = 0.091 in.; stack height, L = 7/8 in.; flat deflection, y_o = 0.146 in.; flat load, P = 3000 lb; flat stiffness, K = 19,000 lb/in.; flat stress, S_o = 268,000 psi; and the number of spring elements is 8 ($n = 2$, $m = 4$).

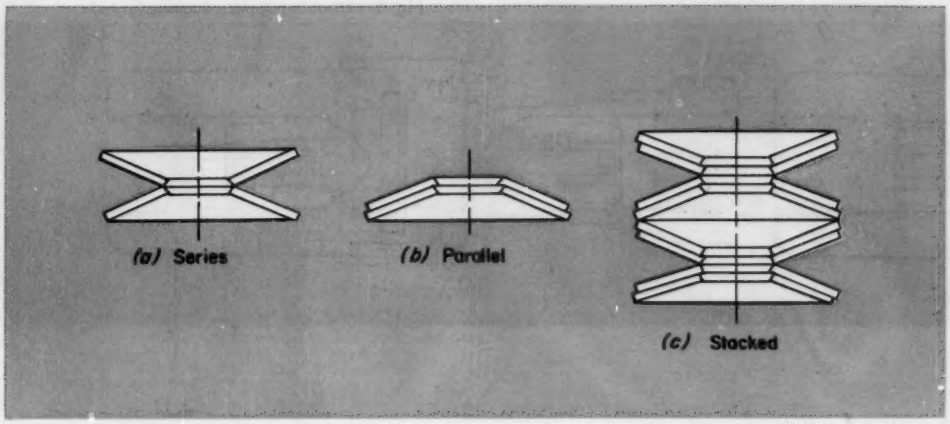


Fig. 5—Typical multiple-spring arrangements.

$$P = nP_o \tag{12}$$

$$K = \frac{n}{m} K_o \tag{13}$$

$$y_o = mh \tag{14}$$

$$L = m(nt + h) \tag{15}$$

Design Characteristics

Conical-disc springs can be pressed flat without permanent deformation, even though the maximum compressive stress calculated from Equation 8 greatly exceeds the nominal yield strength of the material. This is because residual tensile stresses developed in the springs during fabrication partly offset the compressive stresses induced by the external load. Furthermore, examination of the stress distribution existing in a deformed spring shows that the maximum stress acts only on an infinitely small annulus of material surrounding the hole.

As deflection of the spring continues, this stress increases until it reaches the yield strength of the material. Deflections beyond this point then cause the annulus material to go into the plastic stress-strain range, while adjoining sections of the spring still in the elastic range take over the additional load. When the load is finally removed the spring will, for all practical purposes, return to its original height if the localized failure has not affected an appreciable amount of the spring material.

For conical washers that must withstand 500,000 load cycles, a typical maximum allowable stress is 200,000 psi.[3] Where the loading is essentially constant, there seem to be no established criteria for selecting a value of S_o that, when used in the design equations, yields a spring that is just barely free from permanent deformation. For such critical cases the designer must rely on experimental data. In the case of prestressed, heat-treated steel springs, limiting values of S_o from 300,000 to 700,000 psi are not unreasonable for certain dimensional combinations. Successful application of the design charts and equations, therefore, depends a great deal on a judicious selection of a limiting stress, S_o, suitable for the type of loading and for the properties of the formed spring.

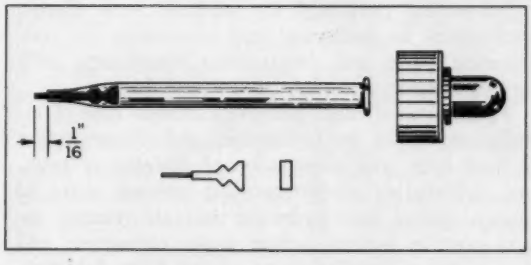
References

1. J. O. Almen and A. Laszlo—"The Uniform Section Disc Spring," *Transactions ASME*, Vol. 58, 1936.
2. A. M. Wahl—*Mechanical Springs*, Penton Publishing Co., Cleveland, Ohio, 1944.
3. *Handbook of Mechanical Spring Design*, Associated Spring Corp., Bristol, Conn., 1956.

Tips and Techniques

Eraser-Fluid Applicator

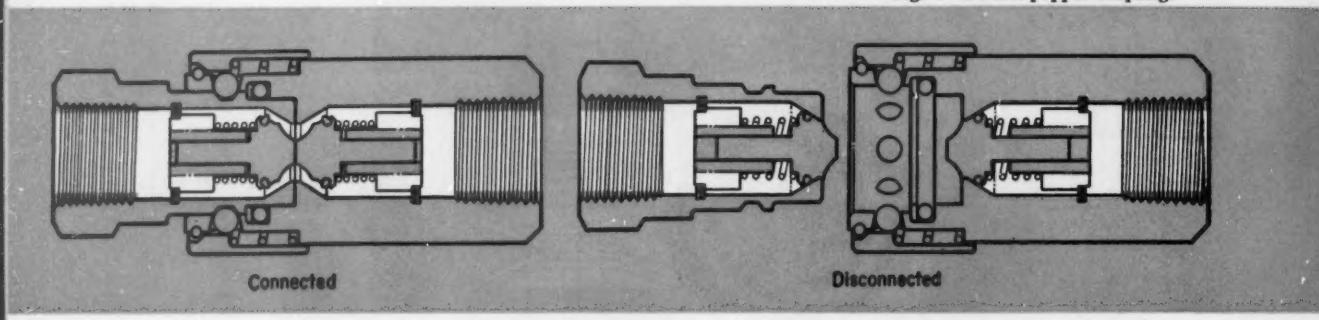
A handy applicator for erasing fluid can be made by inserting a rubber tip into the end of a dropper. Cut the tip from an eraser, as shown, and simply



push it into place. This arrangement provides excellent control over the fluid, eliminating unnecessary smearing.—Karl W. Schmitz, *draftsman, Farris Engineering Corp., Palisades Park, N. J.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, Machine Design, *Penton Bldg., Cleveland 13, O.*

Fig. 1—Double-poppet coupling.



How to select

Self-Sealing Couplings

FLUID lines can be instantly connected or disconnected by the use of self-sealing couplings. No shut-off valves, or other flow disrupting devices, are required.

Basically, these couplings consist of two halves. One contains a spring-loaded leak-proof poppet or seal; the other, a device to open the valve when the two parts of the coupling are connected.

Self-sealing couplings are used in such diverse applications as residential and automobile air conditioning, farm and construction machinery, military equipment, and plant equipment.

Advantages of these couplings include ease of installation, speed in connection and disconnection of fluid lines, and elimination of draining or priming. Self-sealing couplings must prevent entry of foreign matter into hydraulic and air systems, assure positive locking action when connected, and permit the required amount of free flow. Additionally, the couplings must be of sturdy construction for long and trouble-free service.

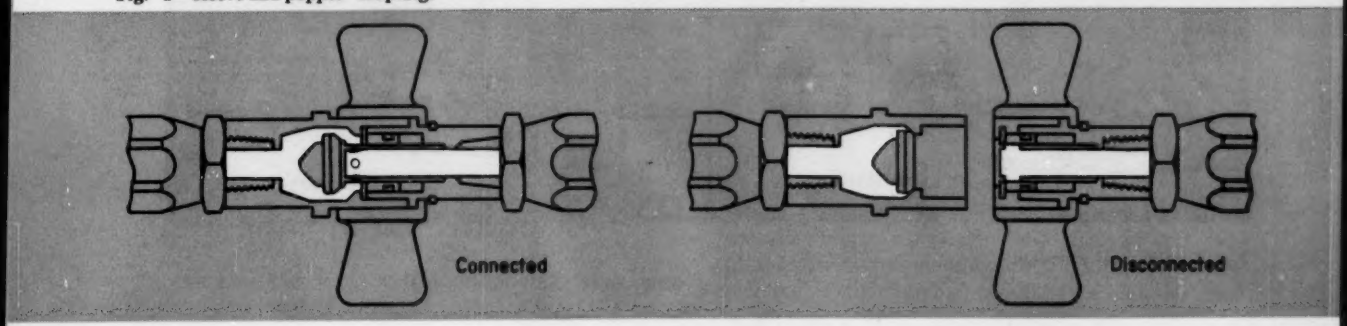
Selection Factors

To obtain these advantages in self-sealing couplings, three major factors must be considered in selecting a coupling for a particular application.

System Characteristics: The fluid to be used determines the types of materials required to prevent corrosion of the metals, damage to the seals, and changes in fluid characteristics. Other necessary information includes range of fluid operating temperatures, ambient or outside temperature range, system pressure, proof pressure (usually 150 per cent higher than the operating pressure), and bursting pressure (or point of failure). Bursting pressure must be 250-300 per cent of the operating system pressure in aircraft and missile applications, and about 400 per cent in industrial use.

Operating Data: Necessary information here includes required free flow and allowable pressure drop. Also, the amount of leakage or air inclusion that is permissible while disconnecting or connecting must be established. Some types of self-sealing couplings are leakproof during the connecting and disconnecting process. Others permit a slight leakage during connection or disconnection. This amount is specified as the maximum permissible fluid loss or air inclusion during each connection or disconnection. Another factor is whether the coupling must be connected or disconnected against pressure. If so, the frequency of operation must be determined.

Fig. 2—Sleeve-and-poppet coupling.



for hydraulic and pneumatic systems

RAY H. KING
Product Engineer
Aeroquip Corp.
Jackson, Mich.

Maximum Dimensions: Finally, what are the maximum allowable envelope dimensions? Is a ball latch or a quick-lead thread required for quick connection or is a regular thread satisfactory? Does the particular application require a push-together, a manual, or a remote-type coupling? Does it require a mounting flange, a boss mounting, or a bulkhead jam nut? What are the weight specifications? What size end connections (male or female) are required?

Basic Types

There are four basic types of self-sealing couplings—double poppet, sleeve and poppet, slide seal, and double rotating ball.

Double Poppet: This type, Fig. 1, has a self-sealing poppet in each coupling half. As the coupling halves are brought together, the external seal is engaged by the male body. Then, the two poppets touch each other. Further movement disengages the poppets from their sealing surfaces. The air trapped between the two poppets enters the fluid system and this volume is immediately filled with the system fluid. Maximum flow occurs when the coupling halves are fully connected.

Upon disconnection, the two poppets are fully closed before the two coupling halves are disengaged from the seal. The fluid that is trapped between the two poppets spills out as soon as the external seal is broken.

The leakage and air inclusion are the major disadvantages of this type coupling.

However, advantages include the fact that the poppet seals are the most positive of any of the self-sealing couplings. This type of coupling is used in vapor and liquid systems for fuel and oil, in hydraulic supply and return systems, and in low-pressure cooling circuits for electronic equipment.

Sleeve and Poppet: This type, Fig. 2, has a self-sealing poppet in one coupling half and a tubular valve and sleeve arrangement in the other. The hollow, stem-like valve has ports around the outer surface near one end. The sleeve covers the ports of the tubular valve when it is closed. Both the poppet and sleeve are spring loaded. When the coupling halves are brought together, the seal on the end of the sleeve engages the body of the opposite half. Thus, an external seal is formed to prevent leakage. The poppet and the head of the tubular valve contact as soon as this seal is formed. Thus, there is no space for trapped air. Further movement causes the tubular valve to push open

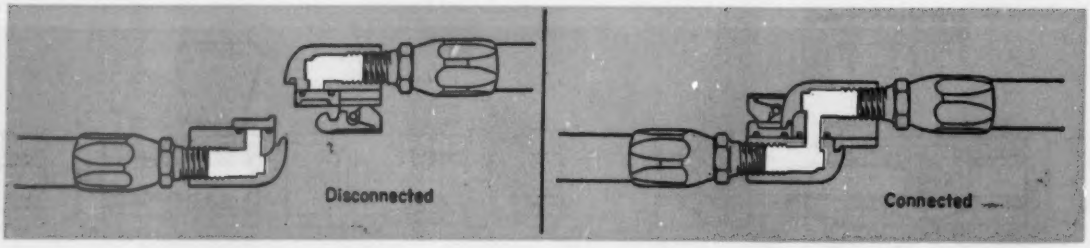


Fig. 3—Slide-seal coupling.

the poppet valve. At the same time, the coupling body of the poppet-valve half pushes back the sleeve and uncovers the ports of the tubular valve.

When the coupling halves are disconnected, the poppet and sleeve are fully closed before the external seal is broken. This arrangement prevents fluid loss from the system.

The freedom from fluid loss and air inclusion is the most important advantage of this type of coupling. The system fluid must have lubricity to insure functioning of the sliding seal.

Any system that cannot tolerate air inclusion or fluid escape must use this type of coupling.

Slide Seal: A sliding gate covers the port on each coupling half in the disconnected position, Fig. 3. To connect the halves, the gates are engaged with the indentations on the opposite bodies, and the halves pushed together. The gates covering the ports are pushed back and the ports aligned with each other. The gate-to-body seal then serves as a seal between the two coupling halves.

In the connected position, the only resistance to flow is caused by the two elbows that change the direction of flow. A latching mechanism holds the coupling halves in the fully connected position.

To disconnect, the latching mechanism is released, and the two halves are pulled apart. The gates slide over the ports and seal the system. If the system is under pressure during connection or disconnection, fluid is lost as the gates slide over the ports. The quantity lost depends upon the time required to connect or disconnect.

Double Rotating Ball: Each coupling half contains a ball with a passageway through it, Fig. 4. In the disconnected position, the balls are turned to seal the port in the coupling half. As the two coupling halves are brought together, an external seal is made, and the halves are locked by a latching mechanism. Further movement of the latching mechanism turns both balls 90 deg so that the passageways are in line with the ports of the coupling halves. The air trapped in and between the balls enters the fluid system. In the connected position, the only resistance to flow is produced by the annular grooves at each end of the passageways.

During disconnection, the first movement rotates the balls to close the ports. Further movement then unlocks the two halves. When the external seal is broken, the trapped fluid escapes.

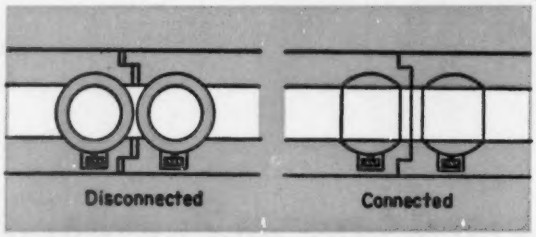


Fig. 4—Double rotating-ball coupling.

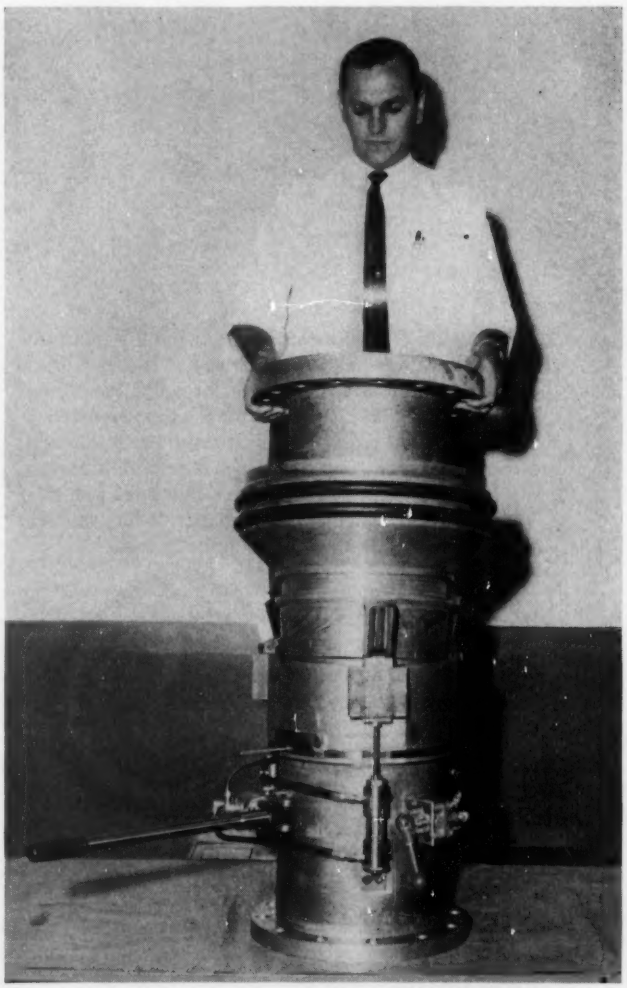


Fig. 5—Coupling for 10-in. diam fuel line.

This type coupling causes only slight pressure drop.

Disadvantages include the large air inclusion on connection, the fluid loss on disconnection, and the difficulty of sealing the balls in the disconnected position.

Additional Variations

Besides the four basic designs that have been discussed, several other variations are widely used.

Single Poppet: Though not a true self-sealing coupling since both halves do not seal, the single poppet is widely used in pneumatic lines where it is necessary to seal the supply-coupling half only. Problems of air inclusion and pressure drop usually do not apply here.

At the other extreme in size is the 10-in. coupling shown in Fig. 5. This coupling, probably the largest single-poppet coupling that has been built, connects ocean-going tankers to land-based supply tanks for the transfer of liquids.

Stem Valve: For low-pressure applications, the valve of the sleeve-and-poppet couplings can be replaced by a stem valve. This arrangement, Fig. 6, reduces the pressure drop as much as 60 per cent. This type coupling is used in refrigerant applications where minimum pressure drop is important.

Diaphragm-Piercing Poppet Valve: Here a secondary inner seal is used to contain the fluid during extended storage periods. In general, the fluid is a hazardous or highly volatile type. When the coupling is connected, a pointed poppet valve pierces the diaphragm to permit flow through the coupling. Since the diaphragm is destroyed by the piercing, each coupling of this type can be used only once.

Concentric Valves: Couplings of this type, used in non-pulsing electronic cooling systems, have one fluid path and valves completely surrounded by another fluid path and valves. This arrangement prevents accidental cross connection of the "in" and "out" side of the system.

Locking Arrangements

In addition to holding the valves open, the lock holds the two coupling halves together. Some method should be provided to indicate when the couplings are properly locked together.

Key Locking: One half of the self-sealing coupling

Fig. 6—Sleeve-and-poppet coupling with a stem valve which provides minimum pressure drop for refrigeration applications.

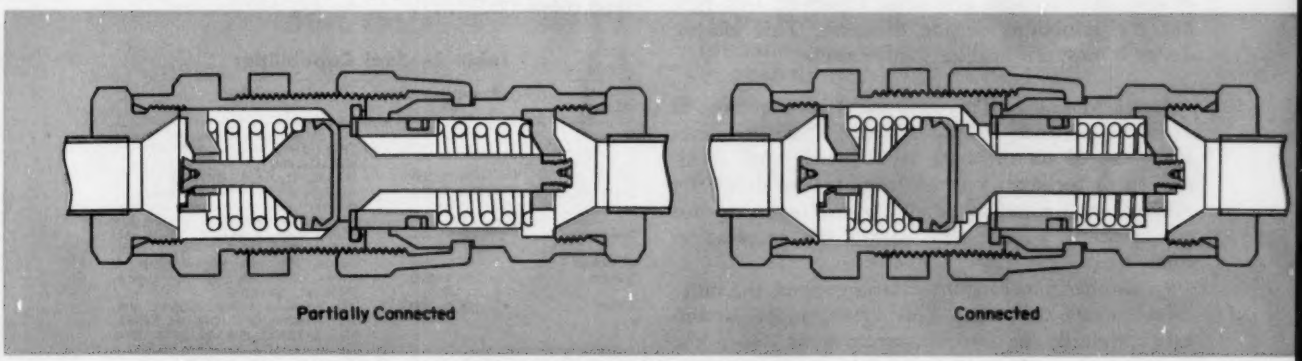
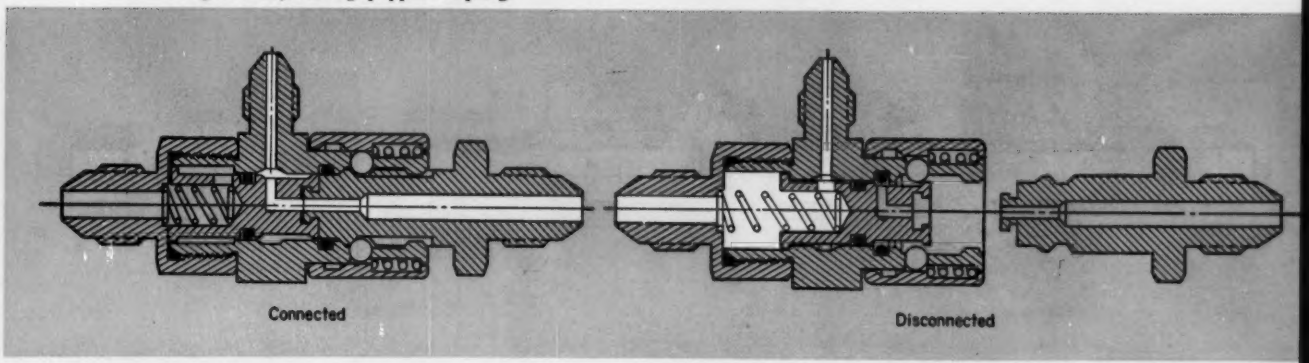


Fig. 7—Key-locking poppet coupling.



acts as a closed valve in the circuit, Fig. 7. The other half serves as the key to unlock the poppet valve in the bulkhead half during filling or checking of the system.

Single-Lead Thread: If time and space limitations are not important factors, this arrangement is the most popular means of connection and disconnection. Technically, however, it is not a quick-disconnect type.

Multiple-Lead Thread: The number of turns required is reduced. This arrangement is particularly desirable on the pressure side of a hydraulic circuit since the load is equally distributed over the large connecting areas.

Push-Pull: Circumferentially arranged steel balls in one half of the coupler engage a matching retaining groove on the nipple. A spring-loaded outer sleeve holds the balls in place. To release, the sleeve is pushed against the spring, and the nipple pulled from the coupler. This design is used in fuel, oil, hydraulic supply and return, and electronic cooling systems. Its simple push-pull action permits installation in tight places.

The major disadvantage is that it cannot be connected or disconnected under pressure. However, in breakaway frames, it can be mechanically pulled apart under pressure.

Bayonet: Locking and unlocking can be accomplished only at low pressures. However, this type has the minimum outside diameter. This locking design is most practical for smaller sizes.

Panel Mounted: The back-panel arrangement is used in electronic cooling systems. The couplings are mounted on the back of a "black box" to allow space for dials on the front of the unit. By pulling on the panel or the box, the union nut automatically releases and allows the coupling to come apart.

In another panel-mounted arrangement, the bulkhead carries the load. This arrangement is also used primarily in low-pressure systems. Since the internal-pressure loads of the coupling are on the bulkheads, both halves can be panel mounted. This type of mechanism permits actuation of the coupling by pulling on the box.

Special: A mechanically opened and closed tubular valve and sleeve-poppet combination, Fig. 8, is available for applications in which the fluids have no lubricity, or have a tendency to leave deposits.

Remote Disconnection

Several methods are available for the remote disconnection of self-sealing couplings.

Interstage Actuated: The couplings are generally bulkhead mounted with the bulkheads carrying the load. When the bulkheads are separated, the coupling is disconnected.

Pull-Away Actuated: With this arrangement, movement of the connecting hose more than 15 deg from center disconnects the ball-locking device of the attaching hose half.

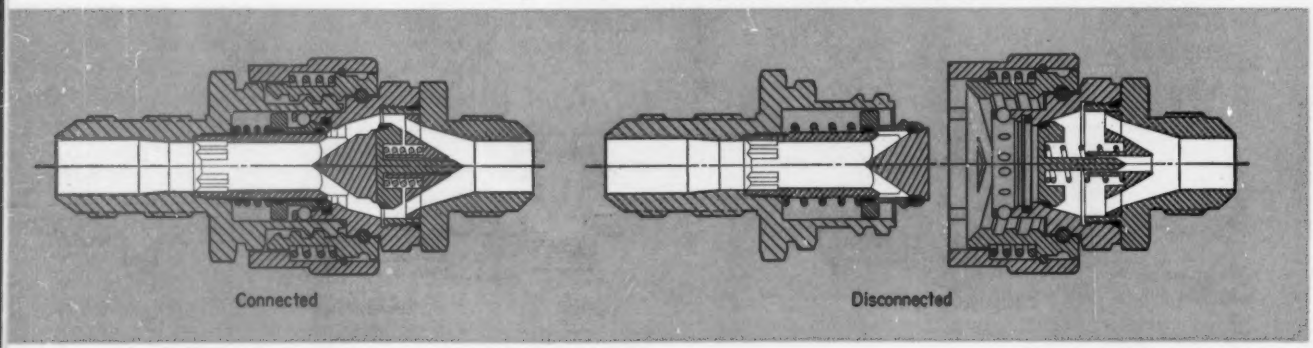
Pneumatic or Squib Actuated: The coupling can be disconnected under pressure because the operating forces can be aligned to exert the pressure necessary to actuate the union nut.

Lanyard Actuated: To date, very little work has been done on this method of disconnecting push-pull type couplings.

Table 1—Seal Capabilities

Seal Material	Temperature (F)	Fluids
Buna N	—65 to 275	Air, gasoline, mineral oil, water, JP-4, JP-5, MIL-L-7808 C, MIL-O-5606
Butyl	—75 to 300	Steam, Pydraul, Skydrol
Natural Rubber	—40 to 200	Ammonia, hydrochloric acid, methyl alcohol, sodium hydroxide, steam, water
Neoprene	—65 to 325	Salt water, Freon 12, Freon 22, MIL-L-7808 C
Silicones	—85 to 550	Gases, hot air, high-aniline oil
Teflon	—100 to 500	Acids, alkalies, gases, steam, Pydraul, Skydrol
Viton	—65 to 450	Air, exhaust gases, silicone oils, MIL-O-8200, MIL-O-8515, OS-45, MIL-L-7808C, DC 200, JP-4, JP-5

Fig. 8—Mechanically operated coupling for use with low-lubricity fluids.



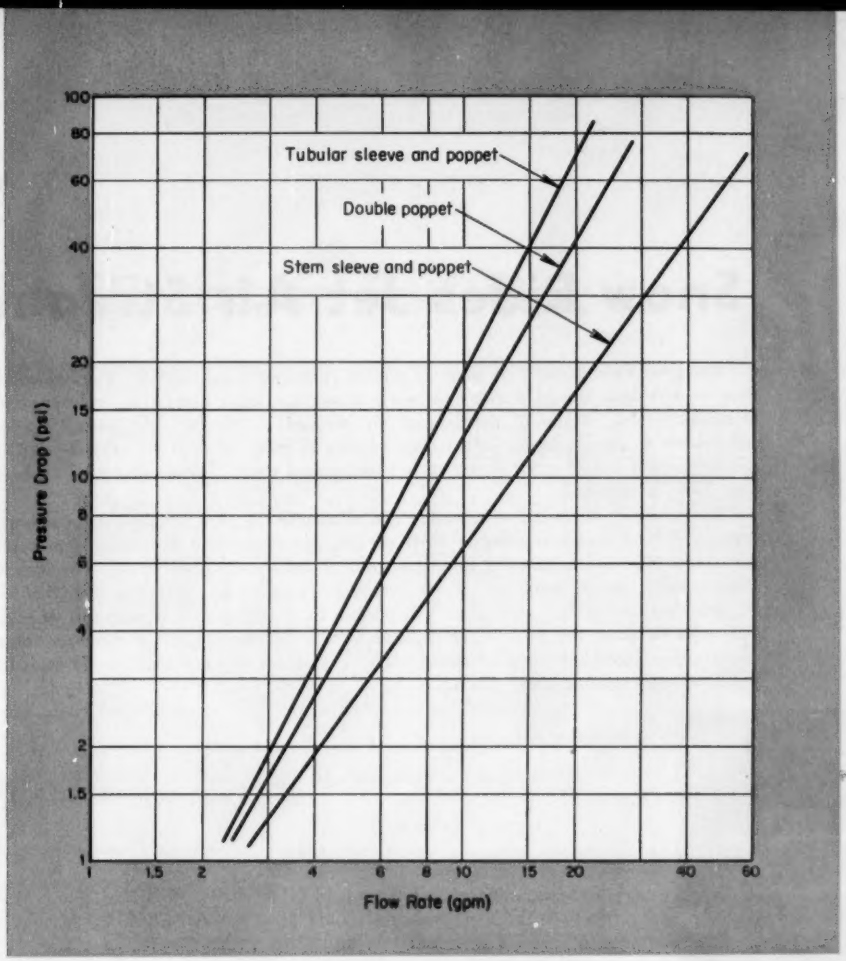


Fig. 9—Typical pressure-drop values for ½-in. couplings.

Materials

Coupling bodies can be made of stainless steel, brass, aluminum, plastics, various bronze alloys, and titanium. The majority of couplings for aircraft use are made of aluminum to reduce the weight.

Stainless steel couplings are generally used with hazardous fluids. Brass, plastic, bronze alloys, or titanium can be used if corrosion resistance is necessary.

Seals

Various seal materials are used, depending upon the fluid. Some of the more common materials are Buna N, neoprene, Butyl, Viton, silicone, Teflon, and natural rubber. Each of these materials can be modified to give the maximum operating life. Table 1 shows seal temperature range and fluid compatibility.

Flow Restriction

Pressure drop depends upon the flow path through the coupling. Thus, each type of coupling has its unique restriction characteristics. Fig. 9 shows typical pressure-drop values for three types of couplings.

Available Capacities

Self-sealing couplings are available in sizes from ⅛ in. to 10-in. diameter. Additional sizes will probably continue to become available in the future.

In general, the maximum operating pressure for standard couplings is 3000 psi. However, this should not be considered the absolute maximum. In some designs, much lower limits are necessary to permit other desired characteristics.

Conclusion

New products, with their constantly changing designs, require that special self-sealing couplings for various fluids, pressures, and temperatures be developed. For example, couplings are necessary for highly corrosive fluids, such as sodium hydroxide; highly inflammable fluids, such as tri-ethyl aluminum; cooling fluids, such as DC fluid 200; and for high-pressure air.

For jet aircraft, a special air-starter coupling is used. It supplies a large volume of high-pressure air to jet engines for starting.

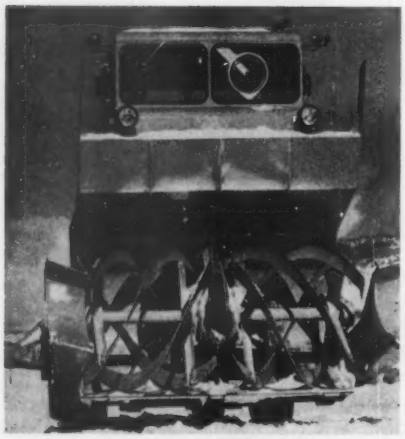
Industrial couplings are available for radioactive fluids and atmospheres; for use in salt-water conditions, such as on amphibious vehicles; or for temperatures to 1500 F.

For many applications, standard couplings can be modified by changing seal materials, basic coupling materials, spring pressures, connecting mechanisms, mounting devices, finishes, and thread sizes.

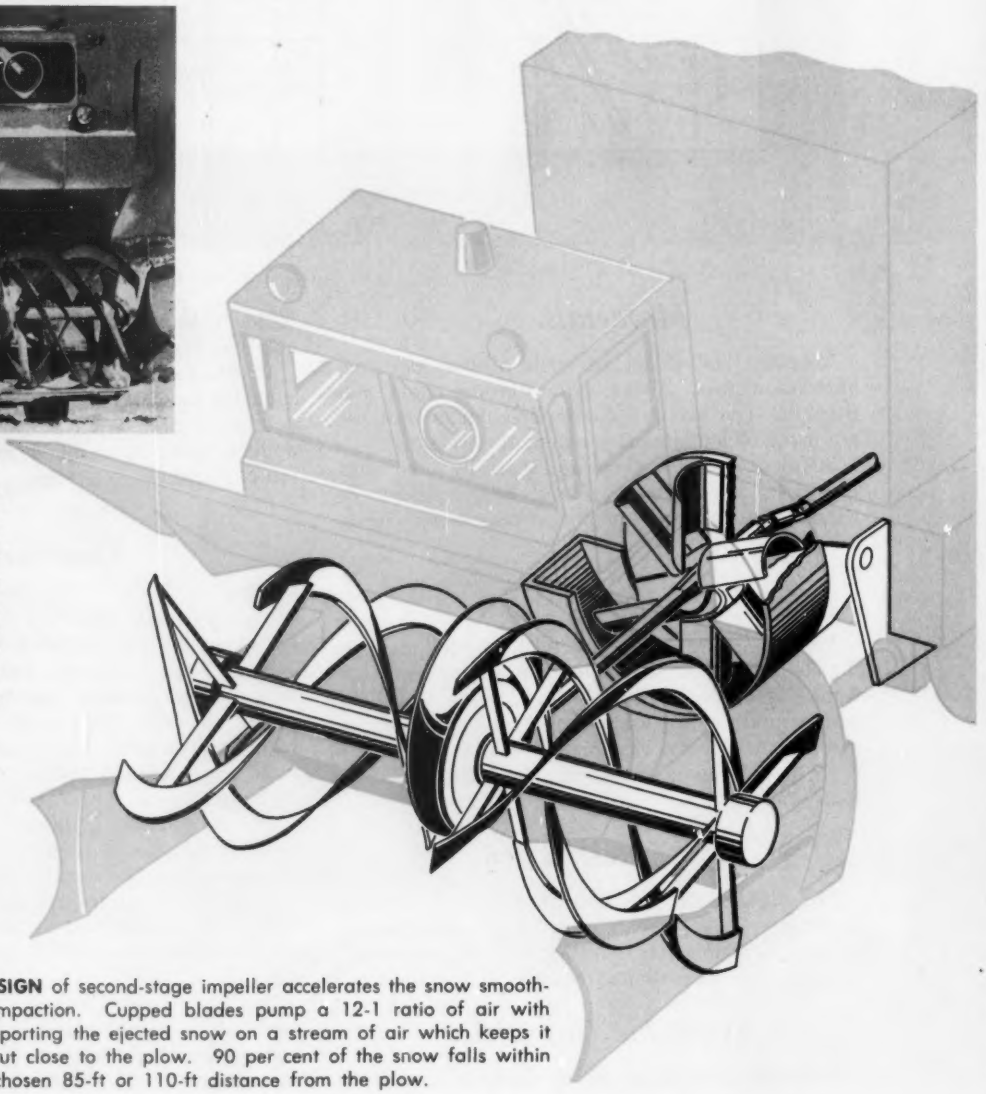
Snow Rides Jet Air Stream

Designers have found that snow in motion resembles a stiff liquid. The Snowblast plow is developed around a two-stage snow pump that leans heavily on hydrodynamic design principles. Many of the features are dictated by the fact that snowplows are called upon to handle snows with weight varying as much as 1000 per cent—from 5 lb per cu ft (fluff snow) to 45 lb per cu ft (hard-packed slush). Shear strength runs from 0 to 1000 lb per sq ft.

To handle these variations smoothly and efficiently the plow is driven by a separate engine. Helical blades, rotating at 50 ft per sec, can be lowered hydraulically to apply pressure to the road surface for forced removal of traffic-compacted snow. The second-stage impeller pumps snow out of the discharge chute on a supporting stream of air at speeds up to 103 fps. The plow will operate in snows up to 7 ft deep and removes 2200 tons of snow per hour. The separate vehicle engine and torque-converter transmission give Snowblast highway speeds from ¼ mph for heavy plowing to 50 mph for travel between working sites.

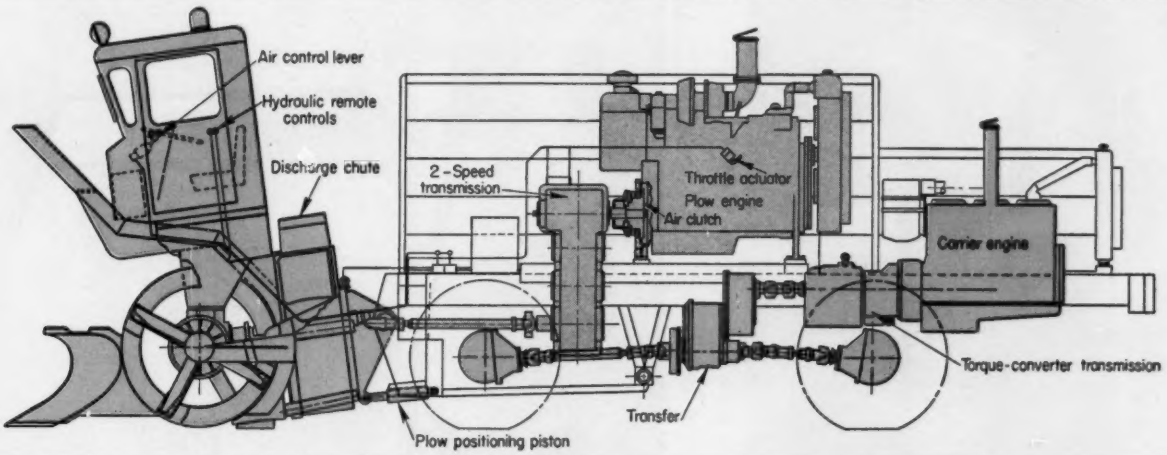


SNOW IS SWEPT toward the center and to the rear by the helical cutter blades. Funneling action drives the snow into the mouth of the second-stage impeller. Speed of the cutter in high gear is sufficient to let it cut snow while the plow is moving ahead at 30 mph.

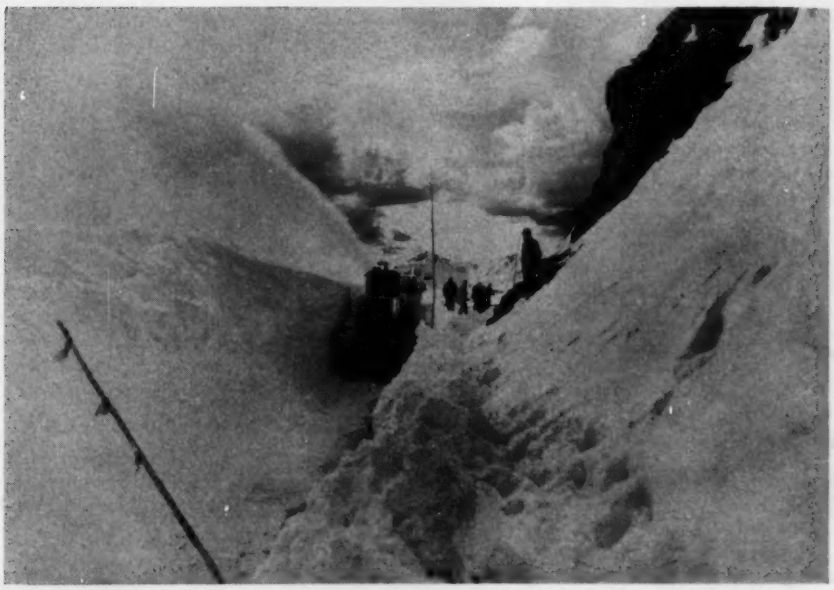


PUMP-LIKE DESIGN of second-stage impeller accelerates the snow smoothly without compaction. Cupped blades pump a 12-1 ratio of air with the snow, supporting the ejected snow on a stream of air which keeps it from falling out close to the plow. 90 per cent of the snow falls within 10 ft of the chosen 85-ft or 110-ft distance from the plow.

To Eliminate Fall-Out



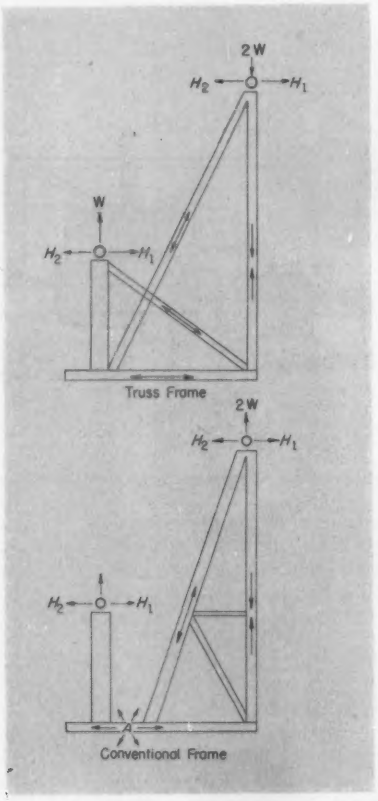
SERVO CONTROLS for steering permit the operator cab to be mounted on the plow ahead of the discharge chute where visibility is better. Air-control lever operates air clutch, transmission, and throttle of the plow engine. A separate carrier engine aft balances the overhang of the front-end plow. Hydraulic pistons raise and lower the plow and direct the discharge chute.



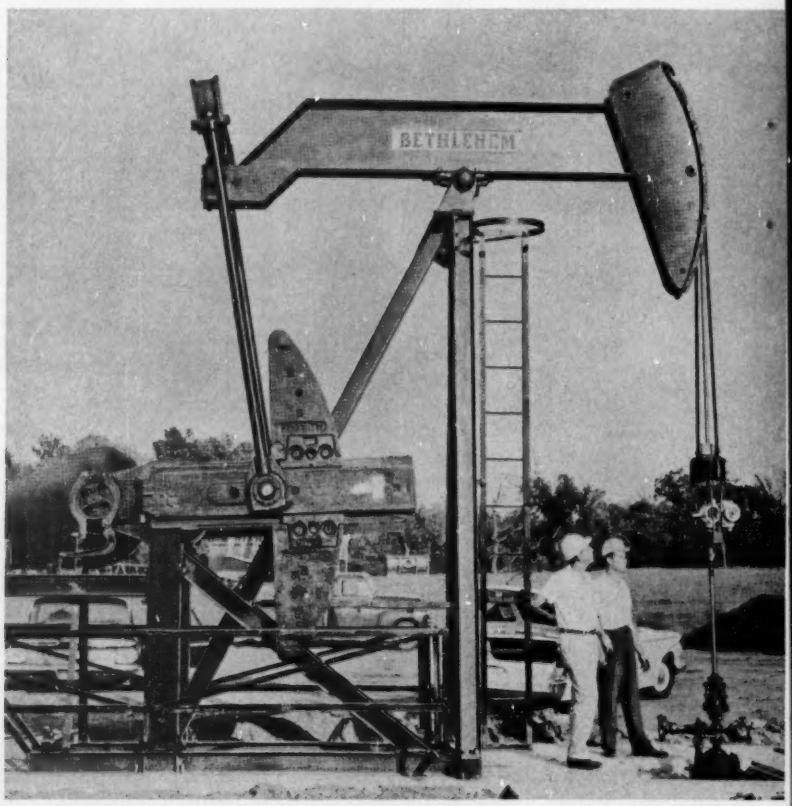
SNOWBLAST is a development of American Snowblast Corp., Denver, Colo.

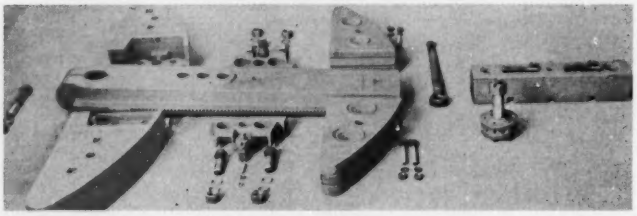
Truss Design Eliminates Bending Moments in Pump Frame

MAXIMUM capacity-to-weight ratio was the goal behind the series "60" pump design. Borrowing a page from bridge engineering, the designers planned a truss framework that effectively eliminated bending moments in the base and samson post. Practically all loads are transmitted by members in tension or compression.

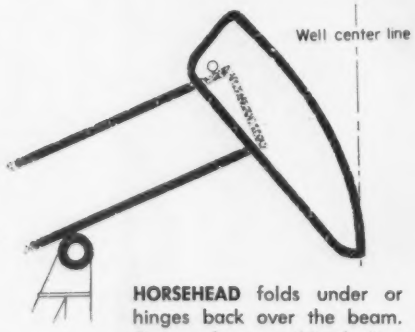


BENDING STRESSES at A are introduced by operating forces H_1 and H_2 in the conventional pump frame (lower). In the new truss frame (upper) these forces are completely supported by members in tension or compression.





VERSATILE counterweight is a shell with interchangeable insert weights to compensate for variations in length of shaft and load. Effective moment arm of counterweight can also be changed to conform to change of stroke length.

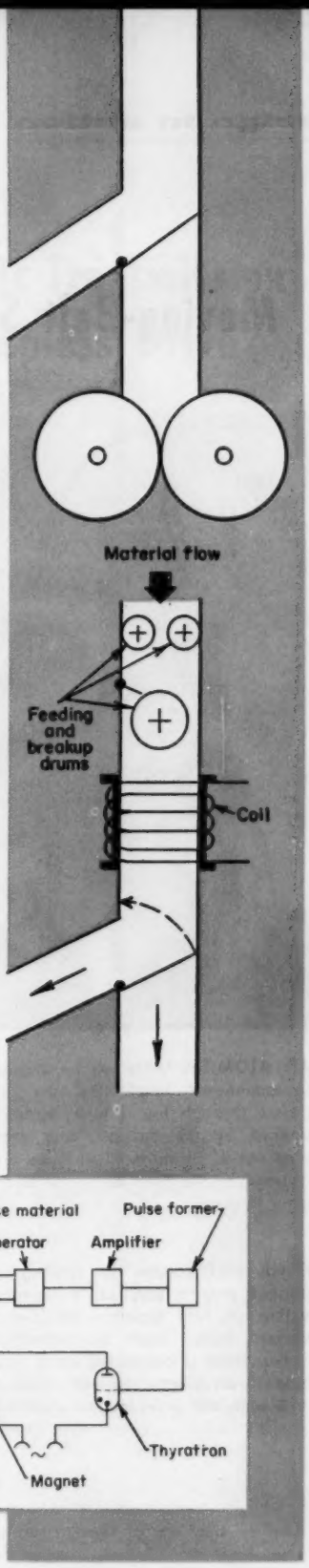


HORSEHEAD folds under or hinges back over the beam. A ground-operated latch does the job. This safety device eliminates need for crew members to climb on the beam during well servicing.

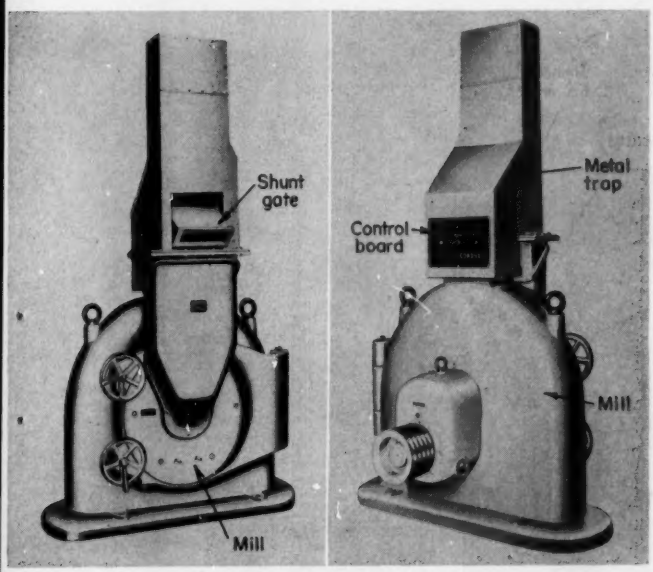
FOR SHIPMENT the series "60" knocks down into a compact package. Pictured unit, called size 114, measures 16 ft 5 in. x 6 ft 2½ in. x 3 ft 8½ in. Pump was developed by Bethlehem Steel Co., Tulsa, Oklahoma.

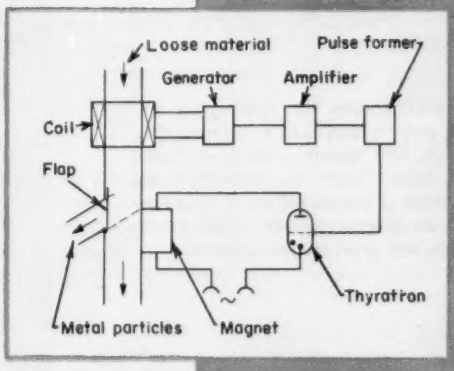
Gate Control • Detects • Removes Foreign Particles

PROTECTION of powder mills from occasional nails or metal pieces mixed with incoming material is easily accomplished with a magnetic sensor. It operates a shunt gate to deflect the undesired particles out of the feed chute.



FEEDING and breakup drums keep loose material from clogging chute. Coil wrapped around the chute changes induction characteristics when metal is in its field. This produces a pulse signal which momentarily closes a flap deflecting the metal particles out.

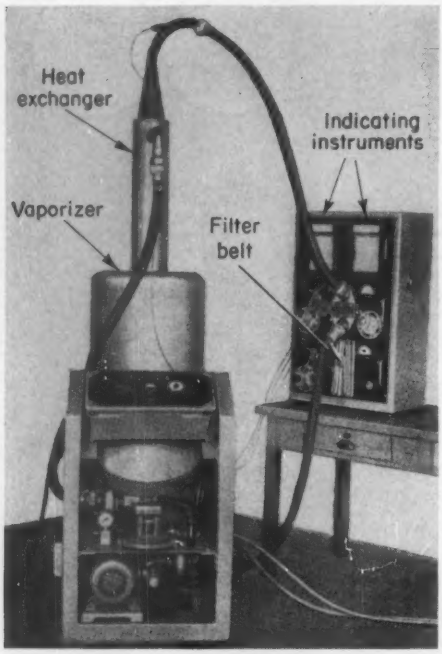




SIGNAL from the induction coil passes through an amplifier and pulse former to give it the right size and shape to trigger a thyratron. The thyratron closes the circuit of magnet operating the shunt flap.

EVEN NON-FERROUS foreign particles may be shunted out by choosing a higher frequency to increase the detector's sensitivity. Shunt control was developed by Condux-Werk KC, Wolfgang bei Hanau, Germany.

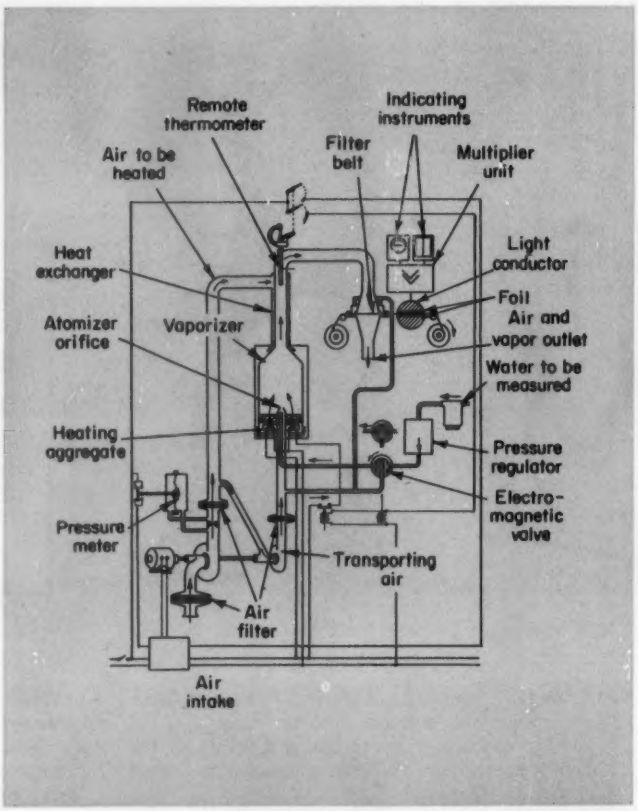
Moving-Belt Still Spots Hot Contamination



RADIOACTIVE impurities in a flow of water are given a running check in a distilling system that traps the offending impurities on a filter belt and passes them before a scintillation counter. Results are registered on a continuous-line recorder. After a short time (measured by filter-belt travel), a second reading is taken of remaining longer-lived radioactivity. Design is by Frieseke & Hoepfuer GmbH, Erlangen-Bruck, Germany.

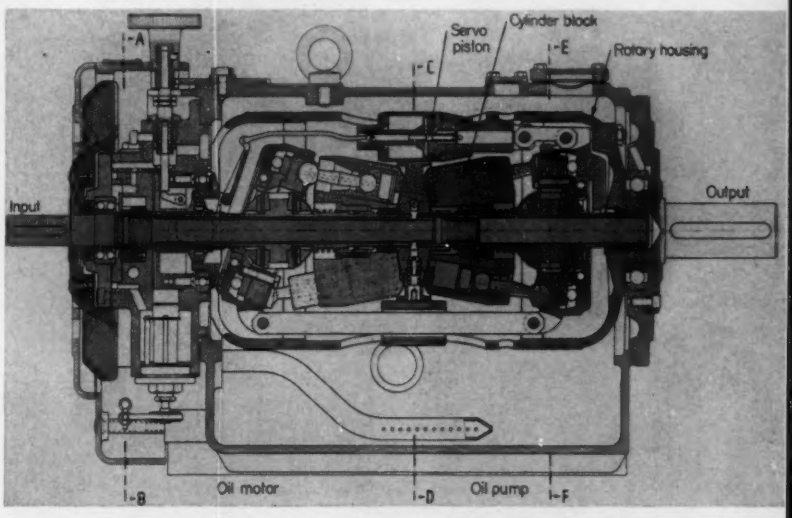
AIR ATOMIZES water to be checked for contamination level. As the mixture passes through the U tube, water is vaporized by the hot air, and impurities pass out of solution. Impurities are then trapped by the filter belt; air and vapor pass through.

FILTER BELT carries the radioactive impurities past a scintillation counter consisting of two radiation-sensitive, luminescent foils. Light generated by the radioactivity is converted by a multiplier tube to an electric current which fluctuates with the level of radiation.

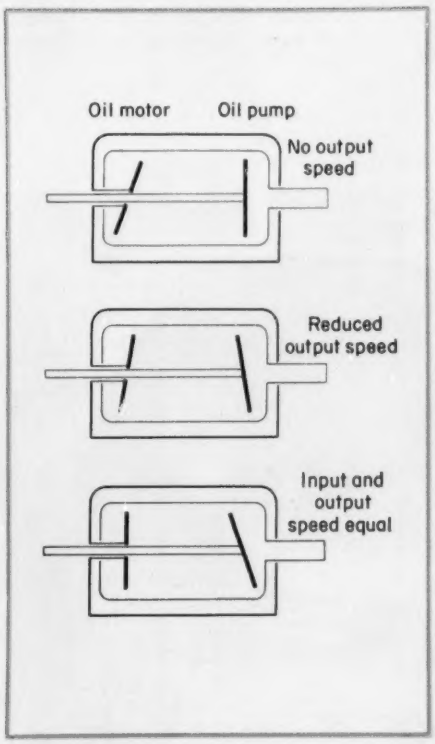


Packaged Hydrostatic Transmission Splits Power for Stepless Drive

IDENTICAL wobble-plate axial-piston units—one acting as a motor, the other as a pump—are mounted facing each other in a hydrostatic speed reducer. Ratio is changed by adjusting angles of the wobble plates, which are linked together through a servo cylinder. Input shaft rotates cylinder block of the pump; output is connected to wobble plates.



Hand-wheel servo control shown can be replaced by an electro-hydraulic servo system. Design is by Flender, Bocholt, Germany.



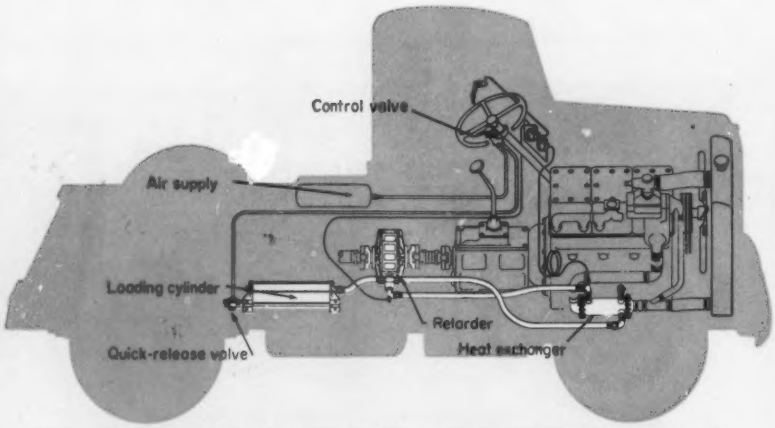
1 **With pump wobble plate normal** to the axis of rotation, no motion is transmitted by the pump, either hydraulically or mechanically.

2 **With both wobble plates inclined,** a split power path is established: Reaction of each pumping piston tends to rotate the wobble plate; fluid pressure drives motor pistons against the wobble plate, tending to rotate that plate too. Sum of torques produces a net output torque.

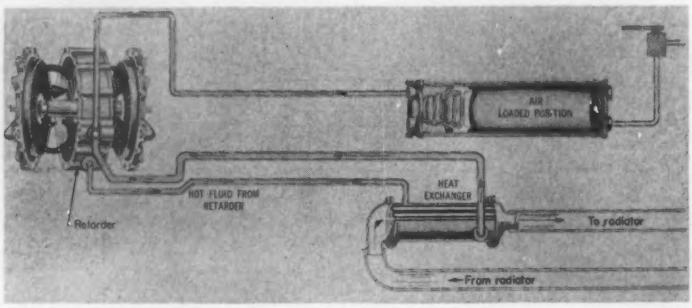
3 **With motor wobble plate normal** to the axis of rotation, motor-piston stroke is zero. Drive is entirely through the pump wobble plate, with the rest of the unit acting as a high-efficiency hydrostatic clutch.

2 Fluid Systems for Dynamic Braking

DOWNGRADES put severe strains on transmission and brakes of heavy trucks. Holding a reasonable speed on hills may tax brakes designed for short-term, high-energy stops. Two recent retarder designs tackle this problem by dissipating energy in hydraulic work-to-heat converters.



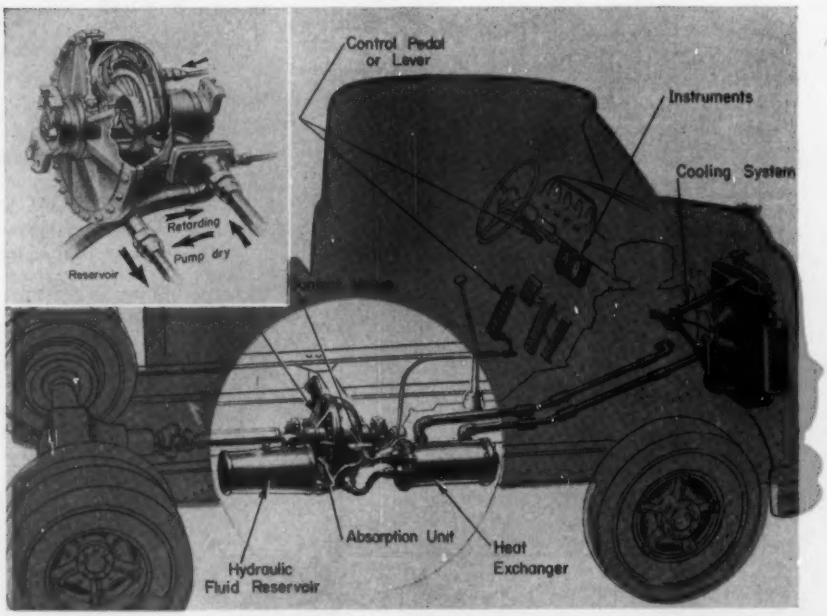
1 **AIR-OVER-OIL** system loads the retarder unit. Energy absorbed by heavy viscous oil is dissipated in heat exchanger. The three basic components (besides controls) are loading cylinder, retarder, and heat exchanger.



LOADING CYLINDER doubles as a storage reservoir for the fluid when retarding action is not required. To actuate the cylinder, a control on the dashboard is set to the degree of retarding required. Air from the truck's pneumatic system pumps the fluid into the retarder. Energy absorbed is changed to heat which is dissipated through a heat exchanger into the truck's radiator water. Retarder was developed by Thompson Products Michigan Division, Thompson Ramo Wooldridge Inc., Warren, Mich.

2 **CONTROL VALVE** responds to position of pedal and blocks or admits fluid from reservoir and heat exchanger according to operator braking demands. When no braking is needed, the valve is closed, allowing the absorption unit to pump itself dry into the reservoir. As retarding is needed, the valve is opened, allowing fluid to enter the absorption unit. This system was developed by Long Manufacturing Division, Borg-Warner Corp., Detroit.

FAIL-SAFE retarder uses no other vehicle systems for control. Self-contained hydraulic circuit operates by throttling fluid through fluid valve controlled by hand or foot levers.



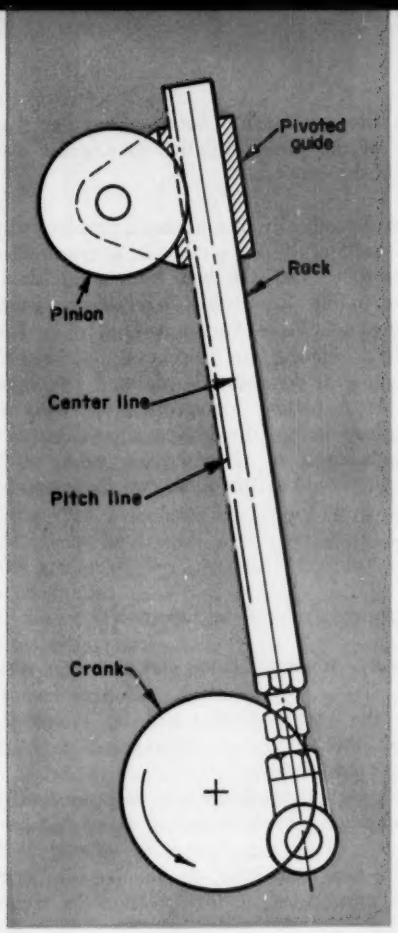


Fig. 1—Inverted slider-crank mechanism. Continuous rotation of crank produces relatively large-amplitude oscillation of pinion.

Design equations for

Inverted Slider-Crank Mechanisms

GEORGE A. BUCCI
Design Engineer
Servo and Mechanics Dept.
Raytheon Co.
Wayland, Mass.

IN APPLICATIONS where large oscillatory motion is required, the inverted slider-crank mechanism is advantageous because of its compactness. However, proportioning the parts to obtain desired displacement characteristics is not easy. Graphical methods, requiring trial and error solutions, are often too tedious. An exact displacement equation can be written and programed for a digital computer to produce accurate results rapidly. But the exact equation cannot be solved easily any other way. This article presents an approximation which can be readily solved on a desk calculator.

Nomenclature

$C = b + R \cos \theta$, for Equations 3, 4, 7
b = Length of tangent from crank center to radius r, in.
R = Crank radius, in.
r = Radius of reference circle, in.
r' = Pitch radius of rack pinion, in.
$S = r + R \sin \theta$, for Equations 3, 4, 7
t = Instantaneous distance between axis of crank pin and point of tangency between the rack center line and reference radius r, in.
x = Distance between pitch line and axis of rack, in.
θ = Angular displacement of crank ($\theta = 0$ deg at point A of Fig. 2), deg
ρ = Angular displacement of pinion from its zero position, rad
ϕ = Displacement of normal to rack pitch line which passes through pinion center, rad ($\phi = 0$ when $\theta = 0$ deg and $\theta = 180$ deg)

The Exact Equation: The inverted slider-crank mechanism, Fig. 1, is peculiar because the pitch line of the rack does not pass through the axis of the crank pin. The rack is guided in a bushing which pivots about the axis of the pinion, and is driven by the crank through an adjusting turnbuckle.

Fig. 2 shows the kinematic significance of offset x between the pitch line and the center line of the rack. The pinion reverses its direction of rotation when the pitch line of the rack is parallel to the theoretical line drawn through crank center O and tangent to a reference circle of radius $r = r' + x$, where r' is the pitch radius of the pinion. Thus, the two reversals of the pinion per revolution of the crank occur when the crank pin axis falls on this line.

As Fig. 2 shows, motion of the pinion is derived from:

1. Angular rotation of the pitch line of the rack around the pitch circumference of the pinion.
2. Linear translation of the pitch line of the rack tangent to the pitch diameter of the pinion.

Let t in Fig. 2 be the general expression for the distance between the crank-pin axis and the point of tangency of the rack center line with reference radius r. Then, at $\theta = 0$, $t = b + R$.

In addition, as the crank rotates through θ, the point of tangency between the pitch line of the rack and the pitch circle of the pinion shifts through angle ϕ. Hence, angular motion of the pinion in radians is

$$\rho = \frac{b + R - t}{r'} + \phi \qquad (1)$$

where

$$t = \sqrt{(r + R\sin\theta)^2 + (b + R\cos\theta)^2 - r^2} \qquad (2)$$

and, with S and C introduced for compactness,

$$\phi = \sin^{-1}\left(\frac{S\sqrt{S^2 + C^2 - r^2} - rC}{S^2 + C^2}\right) \qquad (3)$$

Substitution of Equations 2 and 3 in 1 yields

$$\rho = \frac{1}{r'}(b + R - \sqrt{S^2 + C^2 - r^2}) + \sin^{-1}\left(\frac{S\sqrt{S^2 + C^2 - r^2} - rC}{S^2 + C^2}\right) \qquad (4)$$

In terms of constants and crank radius R, Equation 4 gives the relationship between angular displacement ρ of the pinion relative to angular displacement θ of the crank.

A Problem: Specifically, the author's problem was as follows: Position of the pinion at a crank displacement of $\theta = 180$ deg had been established, and is shown in Fig. 3 as angle A relative to arbitrary reference AA. From Equation 4, at $\theta = 180$ deg, $\rho = 2R/r'$. Hence, the front-center position of the pinion ($\theta = 0$ deg) can be defined by angle $(2R/r') - A$. A further requirement was that at $\theta = \theta_1$, a given value, the pinion should be displaced through angle B. Therefore, a value of R was needed that could satisfy these two independent requirements. From Fig. 3,

$$\rho_{\theta=\theta_1} = \frac{2R}{r'} - A + B \qquad (5)$$

or by substituting θ_1 for θ in Equation 4,

$$\frac{2R}{r'} - A + B = \text{Right-hand side, Equation 4} \qquad (6)$$

from which the unknown R could be evaluated. Moreover, 52 such solutions were required, each for a different value of A.

If, with R known, Equation 4 is to be processed by a digital computer, the programing is straightforward. However, if the equation is to be evaluated by means of a desk calculator, the inverse sine term presents the annoyance of interpolation in trigonometric tables.

An Approximation: If the substitution, $\phi = \sin\phi$, could be justified, mathematical manipulations would be greatly simplified, and the expression for ρ would

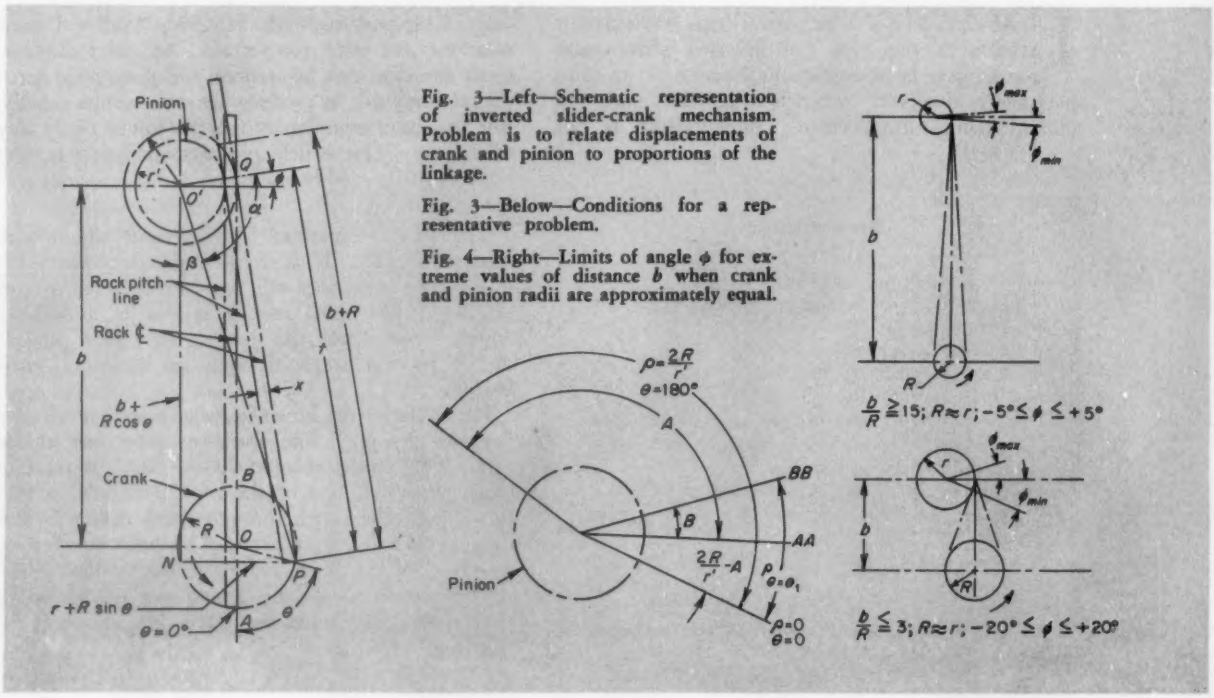


Fig. 3—Left—Schematic representation of inverted slider-crank mechanism. Problem is to relate displacements of crank and pinion to proportions of the linkage.

Fig. 3—Below—Conditions for a representative problem.

Fig. 4—Right—Limits of angle ϕ for extreme values of distance b when crank and pinion radii are approximately equal.

become

$$\rho = \frac{1}{r'}\,(b + R - \sqrt{S^2 + C^2 - r^2}) + \frac{S\sqrt{S^2 + C^2 - r^2} - rC}{S^2 + C^2} \qquad (7)$$

Note at this point, however, that in many cases the pitch line of the rack is made to pass through the axis of the crank pin. For this condition, offset x of Fig. 2 is zero and Equations 4 and 7 can still be used because, for this situation, $r' = r$.

Algebraic solution of Equation 6, using Equation 7 on the right-hand side, results in an expression in the sixth degree of R. It can be readily solved on a desk calculator by trial and error, a method to which the inverse sine term of Equation 4 does not graciously lend itself.

Maximum values of ϕ occur in the mechanism at the points where the center line of the rack forms a common tangent to both the crank circle and reference radius r in the manner of an open and crossed belt, Fig. 4. For large values of ratio b/R (where $R \approx r$), ϕ_{max} is small and $\phi = \sin \phi$ is a valid assumption. For a small b/R ratio ($R \approx r$) ϕ_{max} becomes much larger and presents a condition which does not usually justify $\phi = \sin \phi$. Application of a large b/R ratio to a design is conservative kinematically but space consuming. Use of a small b/R ratio might be discouraged because of excessively high side pressures on the crank pin.

A typical example of a reasonable compromise might be the case illustrated in Fig. 5. Here $b = 11$ in., $R = 2$ in., $r = 1.834$ in. Curve ρ is the graphical representation of the mathematical evaluation of Equation 7 for a complete revolution of the crank. Note, however, that from Equation 1, ρ consists of two terms. The second, ϕ, is also plotted against θ in Fig. 5. Observe that although ϕ attains peak values at $\theta = 100$ deg and $\theta = 260$ deg (at which points errors in the assumption, $\phi = \sin \phi$, are also the greatest) maximum error in ρ does not occur at these points because of the relatively small contribution to ρ by ϕ. The curve of error in ρ shows that maximum error in the value of ρ calculated by Equation 7 occurs at approximately 60 deg. Hence, it is conceivable that mechanisms of the type of Fig. 1 can develop maximum values of ϕ much higher than those ordinarily considered the limit in the assumption $\phi = \sin \phi$ and still be analyzed accurately by means of Equation 7.

For the case depicted in Fig. 5, the most critical point in the cycle is at $\theta = 59$ deg. From Fig. 5, the error in ρ at this point is 0.09 per cent and $\rho = 0.551$ radians. Thus the maximum absolute error in ρ is in the order of 0.000496 radians. Assume that the pinion and rack in the instance cited were of 10 diametral pitch with maximum allowable backlash of 0.005 in. Since the pitch radius of the pinion is 1.500 in., in angular units this backlash represents a lost motion to the pinion of $0.005/1.5 = 0.003333$ radians. Hence, in the worst condition, the backlash inherent in this example will exceed by 90 per cent the error introduced by Equation 7. Therefore, use of the simplified equation is entirely justified.

Conclusion: In practically every case, Equation 7 can be used to investigate the displacement characteristic of an inverted slider-crank mechanism of the type illustrated in Fig. 1. In applications which demand extreme accuracy, and if R is unknown, Equation 7 could first be evaluated for the vital crank radius. Values of ρ could then be obtained by use of both Equations 4 and 7 and the results compared. Should appreciable deviation exist, proper compensation could be made to give the desired accuracy. In 52 investigations performed by the author is which $7 > b/R > 5$ and $1.5 > R/r > 0.8$, values of ρ obtained by means of both equations showed no significant differences.

ACKNOWLEDGMENT

This article is based on a paper presented at the Sixth Conference on Mechanisms, cosponsored by Purdue University and MACHINE DESIGN, October 10-11, 1960.

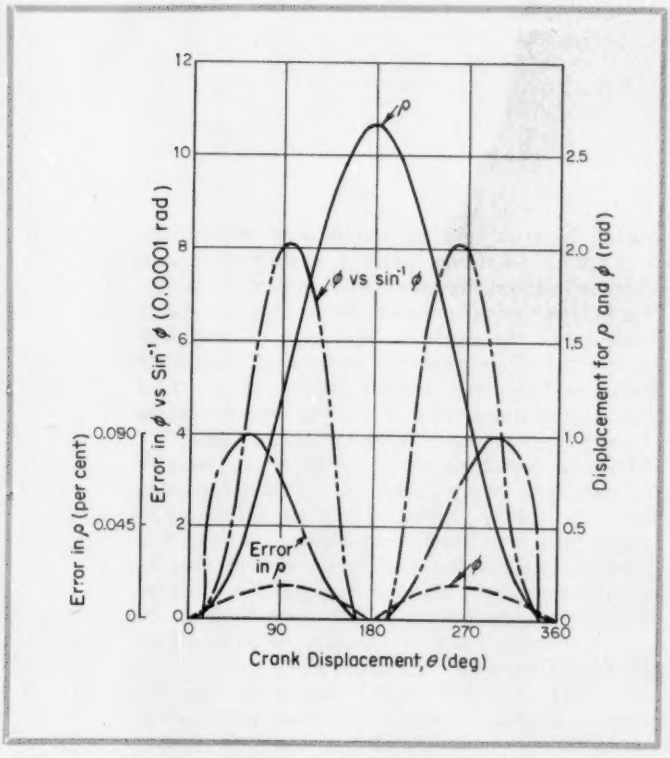
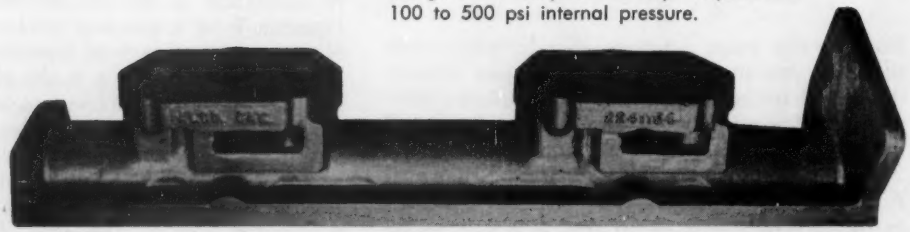


Fig. 5—Effect of the assumption that $\phi = \sin \phi$ on the value of ρ calculated from the approximate expression, Equation 7, where $b = 11$ in., $R = 2$ in., and $r = 1.834$ in.

Transactions of the Sixth Conference on Mechanisms (152 pages), containing the 16 papers presented are available at $2.00 each from Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Typical pressure-tight gray-iron casting: A refrigeration compressor body subjected to 100 to 500 psi internal pressure.



Design guides for

Pressure-Tight Gray-Iron Castings

CHARLES F. WALTON

Technical Director
Gray Iron Founders' Society
Cleveland, Ohio

ARE gray-iron castings too porous for pressure-tight applications? Not at all. Gray-iron castings perform successfully in applications requiring internal hydraulic pressures as high as 20,000 psi.

The ASTM and SAE grades, strengths, and compositions of gray iron used particularly in pressure-tight castings, Table 1, are the same as those for other applications. The difference is that pressure castings require much closer control of the material composition and the casting operations.

What makes gray iron pressure tight? As molten gray iron solidifies, graphite is precipitated out of solution. This carbon assumes its natural flake form and fills out the spaces between the grains of solidifying iron. This action prevents extensive solidification shrinkage.

In addition to nonporosity, factors which contribute to the performance of pressure-tight castings include soundness, strength, machinability, and rigidity.

Soundness: Another solidification phenomenon of gray iron adds soundness to the casting. Just before becoming solid, gray iron is mushy, hence the casting becomes uniform throughout. Gray iron, does not have a strong tendency, as do some metals, to freeze in layers from the outside inward. Solidification in layers tends to cause internal voids or porosity. Evidence of the moderate shrinkage of gray iron castings usually appears on surfaces as dimples or undersize fillets rather than hidden voids. This shrinkage behavior makes it relatively easy to achieve sound castings even in complex shapes, Fig. 1.

For the soundness necessary to assure pressure tightness in a gray iron casting, wall thickness need not be absolutely uniform, but great differences in section thickness should be avoided. A ratio of 4 to 1 between thicknesses of adjoining sections presents no casting problems. Ratios as high as 10 to 1 can be produced in one casting. With such high ratios, special or alloy irons are usually required to get the desired strength throughout the casting.

Naturally, abrupt changes in section thickness inherently weaken a casting and often create stress concentrations. Well-blended changes in section thickness are desirable.

Although sections as thin as $\frac{1}{8}$ in. may be cast in low-strength irons, minimum recommended thicknesses are greater for sections cast in high-strength

Typical pressure-tight gray-iron casting: Crosshead for a diesel engine withstands 1200 F and 1100 psi.

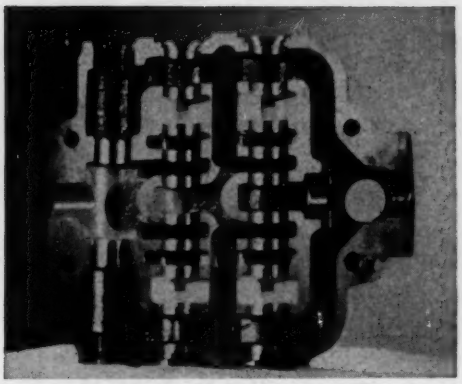


Fig. 1—Spool valve, which carries hydraulic pressure up to 3000 psi, illustrates complexity reproducible in pressure-tight castings.

Table 1—Specifications of Gray Irons for Pressure-Tight Applications

ASTM Spec. No.	Use	Class	Min Tensile Strength (psi)	Hardness (Bhn)	Typical Applications
A 48-60T	Castings not covered by other specifications, and castings in which strength is important.	20	20,000	170-200	Light-weight castings in which appearance and machinability are important.
		25	25,000	175-205	Same as above.
		30	30,000	180-210	Light compressor bodies, pumps, valves.
		35	35,000	190-220	Light compressor bodies, pumps, valves, cylinder blocks, liners, sleeves.
		40	40,000	210-230	Heavy compressors, motor blocks, heads, liners, pumps, valves.
		45	45,000	220-250	Heavy compressors, motor blocks, heads, liners, pumps, valves.
		50	50,000	230-260	High-pressure cylinders, heads, liners, valves, pumps, steam-pressure castings, compressors, rams.
		60	60,000	275-300	Pressure castings, hydraulic cylinders.
A 159-58	Castings with wide ranges of strength and machinability.	110	20,000	187 max	Miscellaneous castings in which strength and microstructure are not primarily important.
		111	30,000	170-223	Small cylinder blocks, compressors and heads, oil-pump bodies.
		120	35,000	187-241	Automotive cylinder blocks and heads, cylinder liners, oil pumps, valves.
		121	40,000	202-255	Truck and tractor cylinder blocks, heads, transmission cases.
		122	45,000	217-269	Heavy-duty castings including blocks, heads, hydraulic cylinders.
A 278-59T	Pressure-containing parts for use at temperatures from 450 to 650 F. (All castings and test bars covered by this specification must be stress relieved by prescribed heat treatment.)	40 50 60	40,000 50,000 60,000		High-pressure valve bodies, pumps, chemical process equipment.

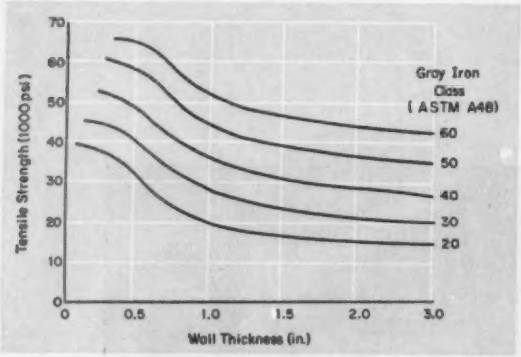


Fig. 2—Effect of casting wall thickness (section size) on the strength of typical gray irons.

Table 2—Minimum Wall Thickness For Pressure-Tight Castings

Class	Thickness (in.)	Class	Thickness (in.)
20	¼	40	⅛
25	⅛	50	⅛
30	¼	60	⅜
35	⅜		

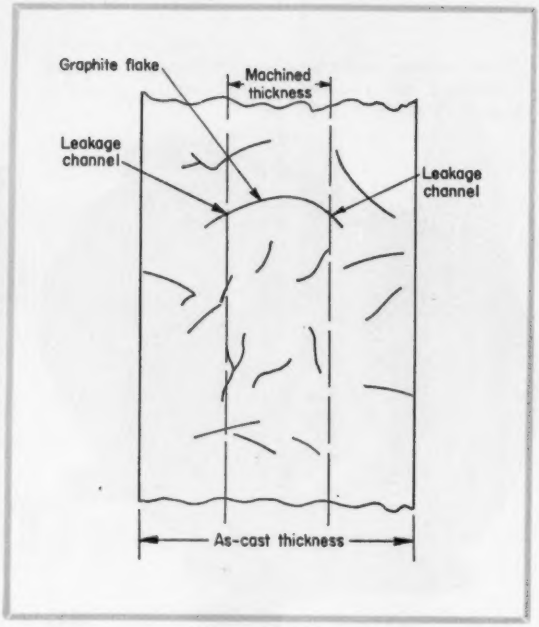


Fig. 3—Excessive machining of casting can create a leakage path through graphite channels.

irons commonly used for extreme pressure and load, Table 2.

Strength: Evidence of pressure-tightness and strength of gray-iron castings is their successful application in hydraulic pumps working at pressures of more than 10,000 psi and in hydraulic rams operating at 20,000 psi.

Because the cooling rate of castings is influenced by section thickness, gray iron tensile strength is greater in thin sections than in thick sections, Fig. 2.

When extremely high tensile strength must be combined with good machinability, designs might combine different types of gray iron. For example, a compressor body could be made of a high-tensile-strength iron and the bores could have inserted liners of a softer iron which is easier to machine.

Machinability: Machining the skin or surface of a gray-iron casting does not make it porous, nor does it reduce pressure tightness. However, the deeper the machining, the more likely that leakage can be caused in an otherwise sound casting. Thick sections have large flakes of graphite. If a thick section were machined thin enough, leakage might occur through graphite channels which extend through the machined section from one face to the other, Fig. 3. Leakage can be avoided by specification of minimum machining allowances for thin sections.

Rigidity: Popular notions to the contrary, gray iron *does* have elastic properties. Ribbing can be used to get maximum rigidity at lowest weight. Compressive strength of gray iron is roughly three times its tensile strength; consequently, ribs should be located on the compression side of castings. Stress concentrations can be prevented by avoiding abrupt terminations at surface intersections. Fillets should have long flowing lines which start at the reinforcement midline and blend smoothly into the sections to be reinforced.

In pressure-tight castings, no direct relationship exists between operating and tensile strength of the iron. Rather, the prime consideration is the load placed on the walls of the casting. The reason for this is that large volumes of liquid under the same pressure as small volumes exert greater loads. Hence, no direct ratios can be applied. Doubling the wall thickness does not necessarily double the strength of castings because gray iron tends to weaken as section thickness increases. Also, there can be no direct ratio between load area and strength because the shape of the casting influences its strength. For example, a circular vessel with a wall thickness of ¼ in. may withstand 1000 psi, but a rectangular vessel with the same wall area and wall thickness might not withstand this pressure because additional stresses may be set up as the sides tend to bow outward.

Of course, stress concentrations should be minimized. Examination of prototype castings can help to locate stress areas. With modern pattern equipment, modification of design is not difficult. Often, metal patterns can be made from plastic or plaster patterns which have been altered many times.

Photo, courtesy Kearney & Trecker Corp.

Spiroid Gearing

Part 3—Materials, Mounting Details, Lubrication

WOODROW D. NELSON, Chief Engineer
Spiroid Div., Illinois Tool Works, Chicago, Ill.

DESIGN of a Spiroid gear system involves three essential phases: 1. Determination of conjugate teeth and gear blank proportions. 2. Selection of materials for strength and durability. 3. Specification of assembly and manufacturing details.

The first two phases have been covered in Parts 1 and 2.[1,2] This article focuses attention on the third phase, dealing with the key factors of bearing loads, mounting details, tolerances, material combinations, lubrication, and manufacturing processes.

Resolution of Tooth Loads

To find the loads on bearings resulting from tooth loads, the normal tooth load (a force vector) at the mean point is resolved into axial and radial components with respect to both pinion and gear axes. Co-ordinates of the mean point are x_m and r_m, Fig. 22.

Pinion Driving: Assume that x_m, r_m, E_P, E_G, m_G, ϕ, C, and T_G (see Nomenclature) are known from previous calculations (Part 2). Then, the total axial thrust which acts upon the pinion and is transferred directly to the pinion thrust bearing is

$$W_{Pz} = \frac{\left[1 - \dfrac{0.995\, x_m}{m_G\, E_P\, r_m} \right] T_G}{\pm 0.10\, x_m \tan \phi + C - 0.10\, r_m} \qquad (48)$$

where the positive sign is used with $\phi = \phi_2$ (high-side driving) and the negative sign is used with $\phi = \phi_1$ (low-side driving). Sense of the thrust force on the pinion is opposite for the two drive sides, as in wormgearing. The thrust force also produces a thrust couple which becomes a component of the radial bearing reaction.

Total radial force on pinion thread at mean point is

$$W_{Pr} = \sqrt{S^2 + U^2} \qquad (49)$$

where

$$S = W_{Pz} \tan \phi \qquad (50)$$

$$U = \frac{T_G}{r_m\, m_G\, E_P} \qquad (51)$$

This radial load on the pinion is transformed

[1]References are tabulated at end of article.

into radial reactions at the pinion bearings by conventional methods of beam analysis and varies according to whether the pinion is straddle mounted or supported as a cantilever.

For the driven gear, the total thrust force upon the gear thrust bearing is

$$W_{Gz} = \mp 0.10\,U + 0.995\,S \tag{52}$$

where the negative sign applies for high-side driving and the positive sign for low-side driving.

Total radial force on the gear tooth at the mean point is

$$W_{Gr} = \sqrt{W_{Px}^2 + (0.10\,S \pm 0.995\,U)^2} \tag{53}$$

where the positive sign applies for high-side driving and the negative sign for low-side driving. Thrust force on the gear, unlike that for a pinion, acts in the same direction regardless of whether the low-side or the high-side is driving.

A Spiroid gear set is left hand or right hand as the pinion is left hand or right hand. Similar to conventional screw threads, a left-hand pinion is one on which the threads twist counterclockwise as they recede from an observer looking along the axis from either end. This convention is illustrated in Fig. 23 which shows the directions of motions resulting from low and high-side driving.

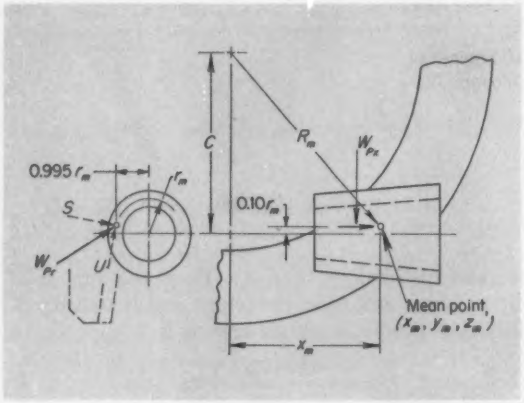


Fig. 22—Resolution of tooth load in Spiroid gear set.

Gear Driving: Gear-shaft torque now becomes the input torque. Under these conditions, pinion axial thrust is a function of gear input torque so that

$$W_{Px} = \frac{\left[1 - \dfrac{0.995\,x_m\,E_G}{m_G\,r_m}\right] T_G}{\pm 0.10\,x_m \tan\phi + C - 0.10\,r_m} \tag{54}$$

where the positive and minus signs apply to high and low-side driving, respectively.

Total radial force on pinion thread at the mean point is

$$W_{Pr} = \sqrt{S^2 + U^2} \tag{55}$$

where

$$S = W_{Px} \tan\phi \tag{56}$$

$$U = \frac{T_G\,E_G}{m_G\,r_m} \tag{57}$$

With the gear driving, the total force on the gear thrust bearing is

$$W_{Gz} = \mp 0.10\,U + 0.995\,S \tag{58}$$

where the negative and positive signs apply to high and low-side driving, respectively.

Total radial force on the gear tooth at the mean point is

$$W_{Gr} = \sqrt{W_{Px}^2 + (0.10\,S \pm 0.995\,U)^2} \tag{59}$$

where the positive and negative signs apply to high and low-side driving, respectively.

Example: Design of a 63:2 gear set to transmit 3 hp at 1750 rpm pinion speed provides the following data (see Parts 1 and 2): $C = 2.25$ in., $r_m = 0.623$ in., $x_m = 1.861$ in., $m_G = 31.5$, $E_P = 0.772$, $T_{G0} = 3530$ lb-in., and $\phi_1 = 10$ deg, which is the drive-side pressure angle. Based on these data, resolve the resulting tooth load into radial and axial components at the mean point.

From Equation 48

$$W_{Px} = \frac{\left[1 - \dfrac{0.995(1.861)}{31.5(0.772)(0.623)}\right] 3530}{-0.10(1.861)(0.176) + 2.25 - 0.10(0.623)}$$

$$= 1435 \text{ lb}$$

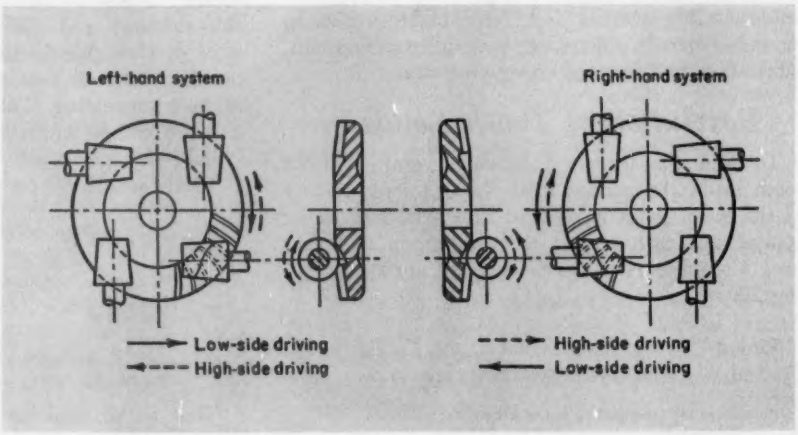


Fig. 23—Right and left-hand Spiroid gearing systems.

From Equations 50, 51, and 49, respectively,

$$S = 1435(0.176) = 253 \text{ lb}$$

$$U = \frac{3530}{0.623(31.5)(0.772)} = 233 \text{ lb}$$

$$W_{Pr} = \sqrt{253^2 + 233^2} = 344 \text{ lb}$$

This radial load, perpendicular to the pinion axis in the plane of the mean point, is used in calculating radial reactions of the supporting bearings elsewhere along the pinion axis.

From Equations 52 and 53,

$$W_{Gx} = +0.10(233) + 0.995(253) = 275 \text{ lb}$$

$$W_{Gr} = \sqrt{1435^2 + [0.10(253) - 0.995(233)]^2}$$

$$= 1460 \text{ lb}$$

These are the thrust and radial loads that must be carried by bearings along the gear axis. If the pinion is driving on the high side, Equations 48 to 53 are used in the same way but with $\phi = \phi_2$ and signs modified accordingly.

Mounting Details

Straddle-mounted pinions and gears provide satisfactory rigidity in a small package, Fig. 24. Maximum rigidity of pinions is provided with the short straddle mounting, Fig. 25; however, there are definite limitations on the size of the inboard radial bearing that may be used.

Pinions and gears may be rigidly cantilever mount-

Nomenclature

C =	Center distance, or offset, in.
d_o =	Pinion outside diameter, in.
E_G =	Efficiency with gear driving
E_P =	Efficiency with pinion driving
F =	Face width of pinion, in.
h_{kr} =	Working depth perpendicular to pinion axis, in.
m_G =	Gear ratio
=	N/n
N =	Number of teeth on gear
n =	Number of threads on pinion
r_m =	Mean radius of pinion at midface and at half the working depth, in.
T_G =	Torque on gear shaft, lb-in.
T_P =	Torque on pinion shaft, lb-in.
W_{Gr} =	Radial component of tooth load on gear, lb
W_{Gx} =	Axial component of tooth load on gear, lb
W_{Pr} =	Radial component of tooth load on pinion, lb
W_{Px} =	Axial component of tooth load on pinion, lb
x_m =	Co-ordinate to plane of mean radius of pinion, in.
ϕ_1 =	Tooth axial pressure angle (low side), deg
ϕ_2 =	Tooth axial pressure angle (high side), deg

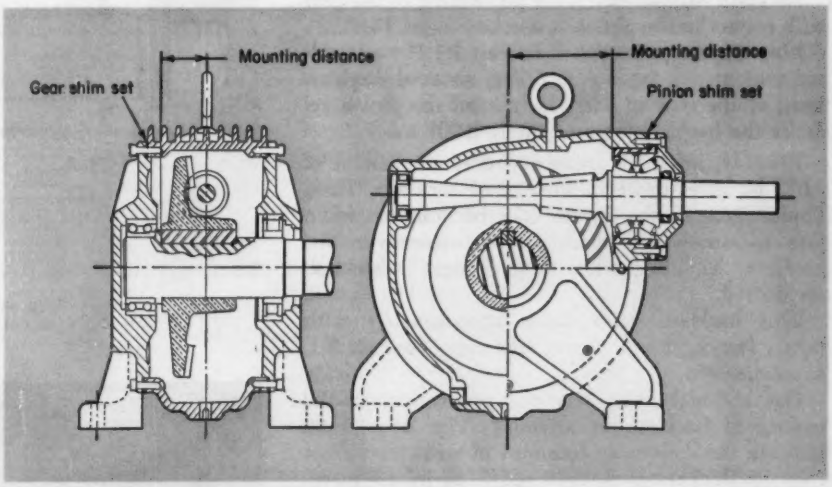
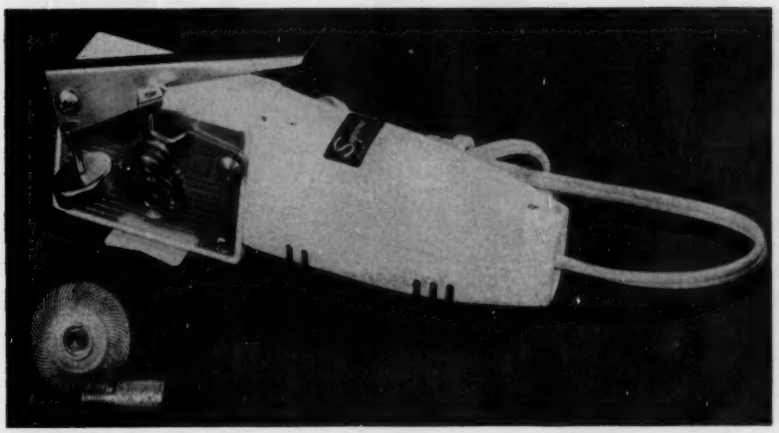


Fig. 24—Typical straddle mountings of Spiroid pinion and gear.



High-production assembly . . . uses sintered iron gear (71 teeth, 1.5 in. outside diameter) and a single thread-milled pinion. These mass produced gears are hardened for strength and wear. (Photo, courtesy Supreme Products Corp.)

ed, Fig. 26, but more space is required for such arrangements. All three of these mounting designs show antifriction bearings; however, sleeve bearings with provision for thrust loads are also practical. Thrust forces from Spiroid gears, as illustrated by the previous example, are substantial. Hence, the bearings to support a Spiroid gear pair must maintain the axial, as well as the radial, positions of both gear and pinion. As compared to antifriction bearings, power losses in plain thrust bearings can be appreciable.

As pointed out in Part 1 of this series, conjugate properties of teeth and threads on a Spiroid gear set are quite insensitive to changes in axial position. For example, withdrawing a 6 in. OD gear of a pair by 0.020 in. gives excessive backlash but otherwise the tooth contact is unchanged. As a result, liberal tolerances in mounting distances and assembly are permissible. For the same reason, Spiroid gears readily adjust themselves to end play such as may be required to accommodate the use of collar-type thrust bearings or the axial play in certain antifriction bearings.

Backlash Adjustment: Axial positioning of the gear with respect to the pinion is one way to get backlash. (Other ways are mentioned in Part 1.) For a standard pinion with taper $\tau = 5$ deg, an axial displacement of the gear of 0.001 in. toward the pinion reduces the backlash approximately 0.001 in.

Roughly, an axial displacement of the pinion of 0.012 in. gives 0.001 in. change in backlash. Thus, displacement of the pinion may be desirable when fine adjustments in backlash are necessary. The gear may be shifted when large changes in backlash are desired.

This backlash ratio varies approximately with $\tan \tau$. Hence, if $\tau = 7$ deg, the ratio becomes 8:1, approximately.

Conventional shim sets are convenient in the control of backlash at assembly. Fig. 24 and 26 indicate the customary locations of such sets. Total shim set thicknesses of 0.040 and 0.080 in. are representative for the gear and pinion, respectively. Sometimes, it is more practical to grind a steel spacer to the thickness required. In certain severe-load applications shims of less than 0.015 in. may extrude out under compression.

Fig. 27 illustrates a threaded bearing cartridge which can be screwed in or out to change pinion mounting distance and control backlash. One advantage of this design is that adjustment can be made after assembly or by maintenance people without dismantling. Another is that large adjustments, such as $\frac{1}{8}$ in., are possible. After adjustment, the cartridge is locked in position by a screw which binds the cartridge threads.

Springs and clips behind the gear to provide a moderate preload on the mesh are common in antibacklash instrument gearing.

Tolerances

Types of tolerances and their magnitudes are based largely upon service requirements and upon manufacturing methods, which vary widely. In applica-

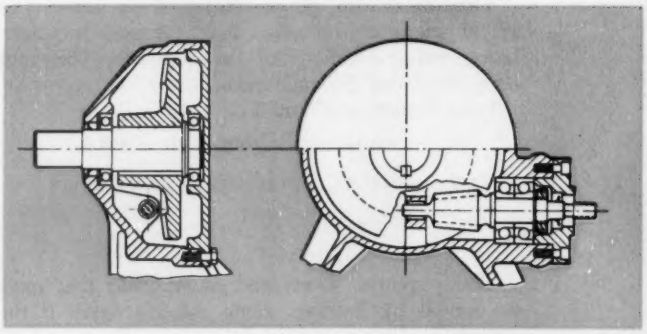


Fig. 25—Typical short straddle mounting of Spiroid pinion.

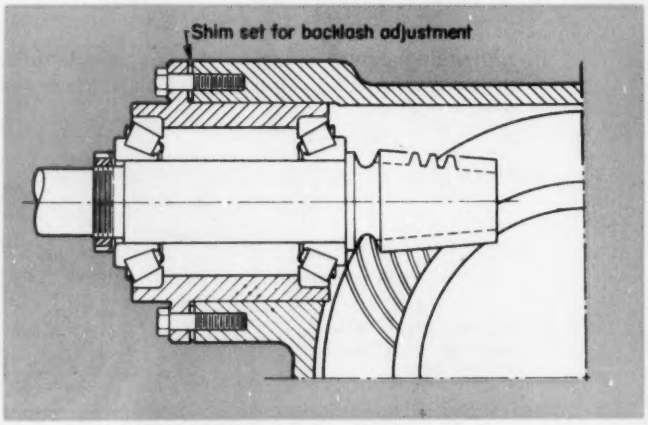
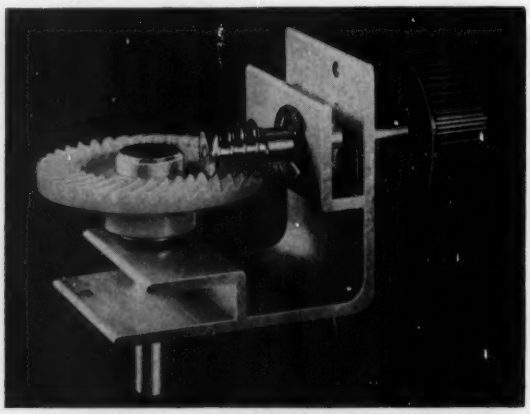


Fig. 26 — Typical cantilever mounting of Spiroid pinion.



Molded nylon gear

. . . and a chased brass pinion find application in light-duty drives for electronic tuners and positioning devices. They form a low cost gear pair and are spring loaded to give zero backlash. Housing is extruded aluminum section.

tions where precision is paramount, Spiroid gears have been designed, manufactured, and assembled to the tolerances recognized as minimum or even not possible for other kinds of precision gearing. At the other extreme, Spiroid gears are used in applications where unusually liberal tolerances are good enough.

Just how liberal the tolerances can be in general is not yet fully settled. Spiroid gears are still relatively new and more service data, particularly long-period performance data, are being gathered. Accordingly, Table 2 presents suggested practical manufacturing tolerances for general use. A manufacturing process like die casting may require modification of these values. For instance, dimensions across parting lines of die-cast gears have to be more liberal than the equivalent dimensions on machined blanks.

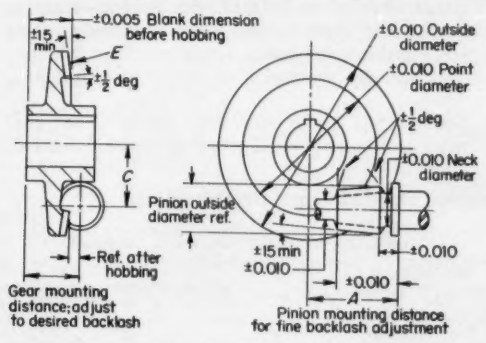
Classes of Spiroid Gearing: While accuracy classes of Spiroid gears are still unsettled, the following are proposed as a guide:

CLASS A is precision quality gearing. It has precision ground pinions. Gears may be precision cut and sometimes lapped. This class includes gears of aircraft quality, but not of the high precision of some instrument or missile guidance system gearing.

CLASS B is high-grade commercial gearing. It is characterized by ground or accurately cut pinions and by accurately cut gears.

CLASS C is commercial quality gearing. Gears are mass-production cut, die-cast, sintered, or injection molded. Pinions may be cut, thread rolled, or even ground from solid.

Table 2—Manufacturing Tolerances



Center Distance C (in.)	Class of Gearing	Pinion Mounting Distance Tolerance (in.)	Center-Distance Tolerance (in.)	Gear Face Runout*, E (in.)	Assembled Average Backlash* (in.)
0.500	A	±0.006	±0.0010	0.0005	0.002
	B	±0.012	±0.0015	0.0010	0.003
	C	±0.018	±0.0020	0.0020	0.004
1.00	A	±0.007	±0.0010	0.0010	0.003
	B	±0.014	±0.0015	0.0025	0.004
	C	±0.021	±0.0020	0.0045	0.005
2.00	A	±0.009	±0.0015	0.0020	0.004
	B	±0.018	±0.0020	0.0040	0.005
	C	±0.027	±0.0040	0.0080	0.007
3.00	A	±0.011	±0.0015	0.0030	0.005
	B	±0.022	±0.0020	0.0060	0.006
	C	±0.033	±0.0040	0.0110	0.009
4.00	A	±0.014	±0.0020	0.0035	0.006
	B	±0.028	±0.0030	0.0070	0.008
	C	±0.042	±0.0050	0.0140	0.012
5.00	A	±0.015	±0.0020	0.0040	0.007
	B	±0.030	±0.0030	0.0080	0.010
	C	±0.045	±0.0050	0.0160	0.015

*Total indicator reading (TIR)

Inspection: An analytical inspection of a Spiroid gear set consists of checking to see that the hob and pinion closely match each other for lead and profile. In a functional check, the pinion and gear are then mounted in their correct relative operating positions in a precision, right-angle skew-axis checking machine. Backlash variation, pinion and gear runout (see Table 2), and tooth bearing may all be checked in this setup.

Materials

Spiroid pinions predominantly are made of hardened steel except for very light loads where free machining brass and dead soft steel have been used. Carburizing grades of steel such as SAE 8620 and SAE 4620 and through hardening grades such as SAE 4150 and SAE 4140 will serve for nearly all designs. The carburizing grades may be carburized or cyanided to 60-62 Rc, as in combinations 1 and 2, Table 3.

For heavy-duty power transmission, gears should be carburized SAE 8620 or SAE 4620 steel forgings or screw stock, hardened to 60-62 Rc.

For moderate loads or precision gears, bronzes have proved to be the best all-around choice. No other material is more likely to perform satisfactorily in places where marginal lubrication or corrosion may occur. Centrifugally cast nickel-tin bronze or nickel-aluminum bronze make the best general purpose red-metal gears, combination 3, Table 3.

Spiroid gear materials for light duty or intermittent service can be sintered iron, die-cast aluminum, or injection molded nylon. Some practical combinations of materials and lubricants are listed in Table 3.

Drawing Call-Outs: The legend on Fig. 1 of Part 1 is typical of information placed on detail drawings of the specification type. Tables 1 (Part 2) and 3 generally contain enough information to complete such drawings.

On the other hand, the legend on production drawings must state the details of heat treatment either in code or spelled out. Thus, an expanded legend to replace that of Fig. 1 (Part 1) might be:

Material and Heat Treatment
SAE 8620 steel
Normalize at 1700-1750
Rapid cool in air to 1200, then slow cool to 600
Gas carburize at 1650-1700 and direct quench in agitated oil
Reheat to 1475-1525
Quench in agitated oil and draw at 300-350
Case hardness, 60-62 Rc
Case carbon content, 0.85-0.95 in first 0.003 in.
Effective case depth, 0.020-0.030 in. finished (Depth to 50 Rc)
Core hardness at base of tooth, 30 Rc

Naturally, process details of this kind vary greatly from one shop or factory to another. Necessary

design information must be based on company, processing, and shop standards.

Lubrication

Because of the many possible combinations of materials in use for Spiroid gearing, no single lubricant is best for all situations. However, general recommendations presented here will cover the majority of design applications.

General classes of lubricants are called out in Table 3 and several greases are identified as representative of specific grades and types.

Oils: The extreme-pressure oils, containing additives such as sulfur, chlorine, and phosphates, are commonly used in automotive, rear-axle hypoid drives. They are referred to as true EP oils.

All organic lubricants change viscosity as temperatures change. Further, they break down at very high temperatures. Thus, oils for high-temperature applications are fortified against oxidation and deterioration in an effort to extend their useful life. Since the "half-life" of lubricating oils occurs for approximately each 22 F rise above 180 F, it is desirable to limit peak operating temperature. Maximum sustained operating temperatures of 200 F are satisfactory; however, lower temperatures will increase the service life.

In steel-on-steel power drives for heavy-duty low-speed or high-temperature service, use oil weight of 140 SUS at 210 F, such as SAE 140 grade.

In power drives for normal duty with pinion speeds up to 3000 rpm or low temperature service, use oil weight of 85 SUS at 210 F, such as SAE 90 grade.

For normal duty with input speeds over 3000 rpm or low temperature service, use oil weight of 60 SUS at 210 F, such as SAE 80 grade (combinations 1 and 2, Table 3).

Mild EP oils usually contain lead napthenate additives. They are suitable only for motion-transmission and light-duty Spiroid gears in either steel-on-steel or steel-on-bronze combinations. Most gear oil suppliers offer a fairly wide range of viscosities (50 to 160 SUS at 210 F) to meet varying requirements of pinion speed and environment temperature.

Best performance is obtained when the oil level submerges the gear mesh.

Grease: It is recommended that individual designs be tested for suitability with greases. The following guides, based on experience, may be helpful:

1. Grease usually can be used with steel-on-bronze or steel-on-steel combinations where generated heat is not a problem and pinion speeds are under 100 rpm. This includes practically all hand-operated Spiroid drives.
2. Small, lightly loaded instrument gearing of any material combination usually can be grease lubricated.

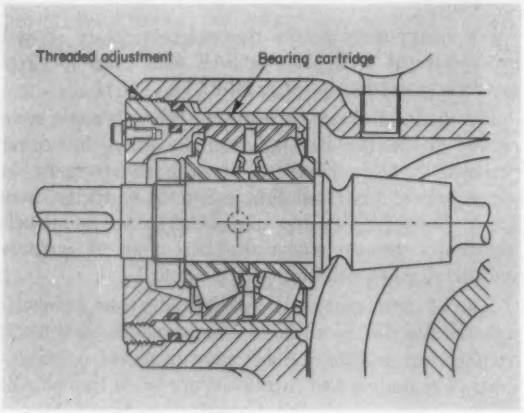
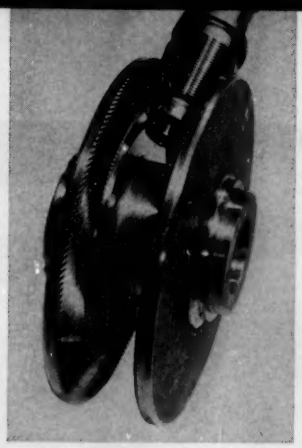


Fig. 27—Threaded bearing cartridge for large axial adjustments of Spiroid pinion.

Table 3—Material and Lubricant Combinations

Pinion	Gear	Lubricant
	1. Steel on Steel	
SAE 8620 or 4620 steel Carburize Harden, 60-62 Rc	SAE 8620 or 4620 Carburize Harden, 60-62 Rc	Extreme-pressure oils of weight and grade to suit speed and load
	2. Steel on Steel	
SAE 8620 steel Cyanide case (90-91.5 R 15N scale)	SAE 8620 steel Cyanide case (90-91.5 R 15N scale)	Extreme-pressure oils of weight and grade to suit speed and load
	3. Steel on Bronze	
SAE 8620 or 4620 steel Carburize Harden, 60-62 Rc (For thin teeth, under 0.050 in., use: SAE 4150 steel; Harden, 56-58 Rc; Ground threads)	Centrifugal-cast nickel-tin bronze 50,000 psi ten str 90 Bhn or Nickel-aluminum bronze 90,000 psi ten str 190 Bhn	For power drives, standard heavy-duty wormgear oils, such as Socony Mobiloil Super 600 W with min viscosity of 150 SUS at 210 F. For light loads, mild extreme-pressure oils of viscosities of 50-160 SUS at 210 F.
	4. Steel on Sintered Iron	
SAE 8620 leaded steel Cyanide case (90-91.5 R 15N scale) Rolled threads	Sintered-iron teeth 60,000 psi ten str 6.4 gram/cc density Particle hardness, 60 Rc	Extreme-pressure oils or greases (See combination 6 for specification.)
	5. Steel on Nylon	
SAE 8620 leaded steel or SAE 1113 steel screw stock, dead soft Rolled thread	Injection molded nylon teeth (Zytel 101) 8000 psi ten str	Most gear oils, or Grease (See combination 6 for specification.)
	6. Steel or Brass on Aluminum	
Free machining brass 60,000 psi ten str or SAE 8620 leaded steel or SAE 1113 steel screw stock	SAE 308 die-cast aluminum (8 Si, 4 Cu) 41,000 psi ten str 26,000 psi yld str 85 Bhn	Greases: 1. K-55 nonfluid oil (N. Y. & N. J. Lubricant Co.) 2. Molybdenum disulphide. 3. Lubriplate. 4. Hodson EP 2048 (Hodson Oil Co., Chicago)



Dual gear drive

. . . provides compact arrangement and can be used when reduction ratios are 50:1 and greater. In this unusual design, the pinion drives two gears keyed to a common shaft. Design approximately doubles allowable shock and durability rating and eliminates need of a thrust bearing for the gears. Gears float axially as an assembly and adjust themselves to share pinion driving torque.

3. Brass pinions on aluminum gears and steel pinions on sintered-iron gears have been run successfully with grease lubrication.

Action of Extreme-Pressure Oils: The mechanism of extreme-pressure action in gear mesh can be triggered by high loads and/or high speeds. Activity increases with contact-line temperature toward a chemical reaction which results in a film of iron sulfide or iron chloride, depending on the additive. This compound forms a tenacious film of anti-weld properties on both members. There is actually a chemical reaction between the base metal of the gears (iron) and the EP additive. As a result of this reaction, there is a slight corrosion of the steel gear. If abrasion has taken place and the extreme-pressure film is broken, the film is quickly renewed when another contact line of sufficient temperature passes over the spot.

During the run-in process, there are essentially two phenomena taking place. One is a surface conditioning process, in which some of the high spots of the minute surface asperities are contacted and rolled over to form a relatively smooth finish. The second phenomenon is the actual removal of metal from high spots due to a shearing or tearing action after pressure welding. The extreme pressure additive in oils tends to reduce or eliminate this latter condition.

It has been found that the mild extreme-pressure oils do not give the effective protection against pressure welding that results from the use of true extreme-pressure oils on hardened, steel-on-steel Spiroid gears.

Manufacturing Processes

Spiroid gears and pinions are made on standard spur-gear hobbing and thread-milling machines, slightly converted. The gear is manufactured by the "facsimile" hobbing process. That is, the cutting tool is a hob, which is an exact geometric replica of the pinion except that it is gashed and has relieved cutting edges as well as stock allowance for backlash and clearance.

In the hobbing operation, the hob and the gear blank are positioned and rotated together at the relative speed of operation of the pinion and gear while the hob is fed sideways into the blank until the gear teeth are cut to full depth. This generating process is analogous to infeed hobbing of a worm-gear except that the Spiroid hob is fed sideways into the gear blank. A Spiroid gear may be finish lapped but it is never ground.

The pinion is the defining member of a Spiroid gear set. It can be made in several ways. A conventional worm-thread mill equipped with a taper-block attachment can be used to thread-mill tapered Spiroid pinions. In this process, an unsymmetrical, double-conical, thread-milling cutter is set at the thread angle and fed automatically along the taper in a timed relation with the rotating pinion blank. The locus of the thread-mill cutter in all of its relative operating positions describes, approximately, a milled helicoidal surface of constant lead, of which only a tapered portion is used for the threads. Since the cutter has unsymmetrical pressure angles, it describes helicoidal surfaces of different taper for each side of the pinion thread.

Another way to thread a pinion is by thread-chasing. In this process a cutting tool, similar to a lathe-type screw-thread chasing tool, is placed so that its cutting edges lie in the axial plane of the pinion. The thread is then chased on a tapered blank. This process may be accomplished on either special automatic-cycling lathes or standard lathes that have properly geared cross slides. Pinions produced in this manner are the simplest to define geometrically since they are of constant lead and have straight-side profiles in any axial plane. Technically, they are tapered portions of screw helicoids.

Thread grinding is usually a finishing process which approximately duplicates the thread-milling operation in principle except that a dressed, double-conical grinding wheel is used instead of a thread-mill cutter. Pinions finished by this process are generally convex in the axial plane and belong to the same mathematical family as the milled helicoids.

When a production run of gear sets is to be made, the first aim is to arrive at a suitable, fast production setup for producing finished pinions. Once a typical production-finished pinion exists, the manufacture of the hob may begin. The hob is made to match the pinion lead and profile and thus becomes a replica of the defining member. The hob is then used to cut the gears.

While the pinion is the defining member, the gear is the conjugate form in the same way that a conventional cylindrical worm defines the conjugate wormgear. As with a wormgear, there are no practical control measurements that can be made on Spiroid gear teeth other than indirectly by functional checking.

In addition to these basic processes of machining Spiroid pinions and gears, pinions have been made by thread rolling, and gears have been made by sintering, die-casting, sand casting, and plastic injection molding.

REFERENCES

This article is the third and concluding part in a series by Woodrow D. Nelson on design and application of Spiroid gearing. Previous articles and issues of MACHINE DESIGN in which they appeared are:

1. "Basic Design Practices" .....February 16, 1961
2. "Durability, Strength, and Efficiency" .....March 2, 1961

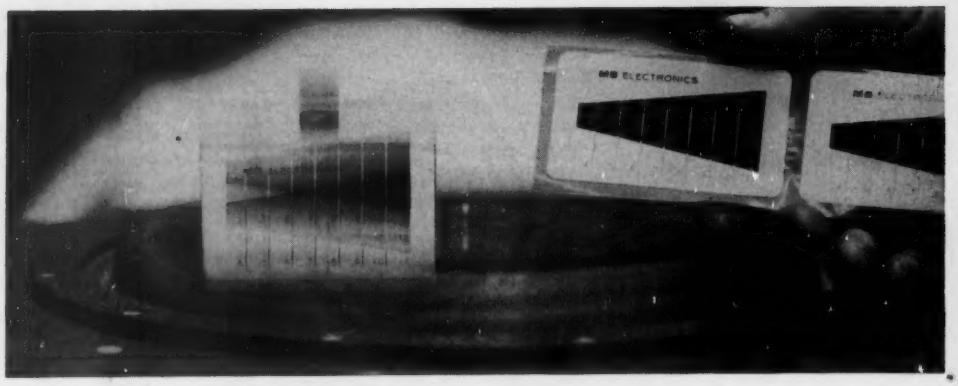


Fig. 1—An optical wedge being used to measure the displacement of a vibrating body.

The Optical Wedge

. . . a simple method for measuring vibration amplitudes

JOHN E. JUDD
Experimental Engineer
MB Electronics
New Haven, Conn.

IN RECENT YEARS, the optical wedge has caught the fancy of engineers as a means of measuring vibratory displacement, Fig. 1. Among its advantages are negligible cost, direct readability, and simplicity. However, this simplicity is deceiving. It does not insure foolproof performance under all conditions.

The optical wedge is a pressure-sensitive sticker that can be fixed to a flat surface on an object under test. In addition to its use with vibration test equipment the wedge can be used, within limits, in a variety of applications where rectilinear motion must be measured.

Is the wedge really a something-for-nothing wonder, or a toy usable only for demonstration purposes? The answer probably lies somewhere between the two extremes.

Operation: The optical wedge is essentially an isosceles triangle whose base is parallel to the plane of the input vibratory motion. The length of the wedge is graduated as shown in Fig. 1.

When the wedge is subjected to rectilinear vibratory motion, two triangles are generated, Fig. 1 and 2. The base of either triangle bears the same relationship to its height as the base of the wedge bears to its height.

Thus, the motion of the apex point, along the horizontal axis of the wedge is related by a constant to the double-amplitude displacement of the wedge.

Limitations: Laboratory tests indicate that the accuracy of the displacement reading obtained from the wedge depends on many factors, including:

1. Magnitude of displacement being measured.
2. Frequency of vibration.
3. Accuracy of wedge dimensions and scale graduations.
4. Observer's experience and eyesight.
5. Optical effects such as the penumbra-like area around the apexes of the white and black triangle.
6. Nonrectilinear motion.
7. Other possible psychophysical phenomena.

In laboratory experiments conducted by MB Electronics, observed errors of 50 per cent were not uncommon. However, results of this cursory survey indicated that errors of less than 5 to 10 per cent may be achieved if:

1. The user is checked against a known standard.
2. The vibratory frequency is over 30 cps.
3. The vibration amplitude exceeds 0.1 in. Smaller amplitudes may be measured, but the degree of possible inaccuracy increases rapidly as the amplitude drops below this value.

Optical wedges presently available are suitable for estimating only those vibration amplitudes which exceed 0.1 in. A similar device for smaller amplitudes is not yet available, although the search is continuing for a configuration suitable for measuring displacements of low magnitude. Tests have indicated that sizable errors are possible in using such devices for small-displacement measurement.

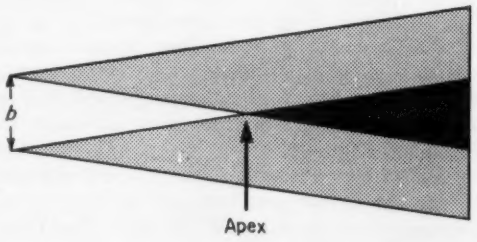


Fig. 2—Triangles generated by vibration of the optical wedge. Dimension *b* is the displacement of the vibrating body.

Calculating Deflections in

Variable-Section Beams

LAWRENCE L. MARGOLIN
Senior Structures Engineer
North American Aviation Inc.
Inglewood, Calif.

Beam theory is the basic for finding deflections of shafts, brackets, cranks, and beams in terms of loads, dimensions of the parts, and stiffnesses of the materials of which the parts are made. The underlying mathematical relationship is expressed in simple and familiar form by

$$\frac{d^2y}{dx^2} = \frac{M}{EI}$$

where M is the bending moment, I is the moment of inertia, and E is the stiffness of the material, commonly called the modulus of elasticity.

Mathematically, this relationship defines a curve, known as the elastic curve of the part or beam, which is the plot of deflection y versus location x along the neutral axis of the beam. Double integration of the elastic curve is the classical and direct way to evaluate deflections. Prior to integration, however, M and I must be expressed as functions of variable x.

For standard beams, I is constant, but for built-up beams and machine parts, I is more likely to be variable and, consequently, not readily expressible as a function of x. Here, tabular values provide the relationship between I and x, enabling the design engineer to bypass the integrations. The tables apply to unit loading under four conditions: One concentrated load, uniformly distributed load, "triangular" loading, and loading by end couples.

CALCULATIONS of slopes and deflections of a loaded beam require integration of the function M/EI. This data sheet helps solve problems where material is uniform but both M and I may vary along the length of the beam. The variation of I can be more conveniently treated mathematically if expressed as a reciprocal, $C = (1/I)$, which is a measure of compliance.

Values of the reciprocals are plotted as ordinates in a C diagram, Fig. 1. Then, the area enveloped by a C diagram is separated into three zones: A rectangle having ordinate C_r, a triangle having ordinate C_t or C_t', and a curve of ordinate C_s, which can usually be approximated by a sine function. This permits expressing the C diagram as the sum of three simple mathematical functions.

Unit diagrams are another expedient. They enable the components, C_r, C_t, and C_s to be expressed as nondimensional ratios. In Table 1 is a unit dia-

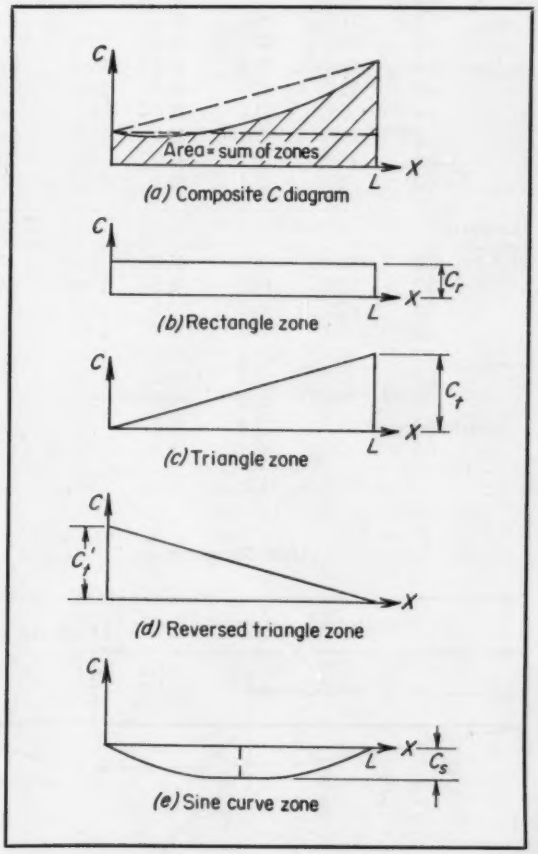
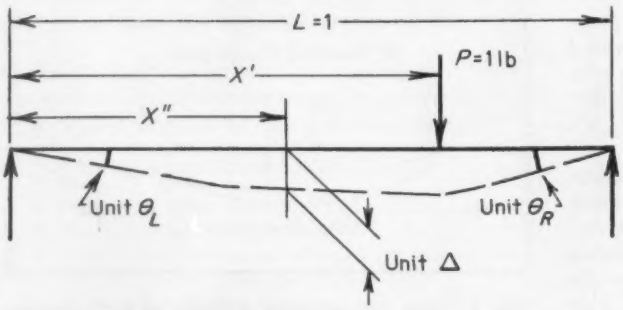


Fig. 1—Zones and maximum ordinates of a C diagram.

Table 1—Simple Beam with Concentrated Load

Rectangle		Linear, $10^4\Delta_r$ (in.)									Angular (radian)	
X″		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	$10^3\theta_{Lr}$	$10^3\theta_{Rr}$
X′	0.1	27.0	46.4	57.9	62.7	61.4	55.5	44.7	31.6	16.3	28.5	16.5
	0.2	46.4	85.7	109.1	119.8	118.1	107.2	87.0	61.4	31.6	48.0	32.0
	0.3	57.9	109.1	147.5	165.0	164.1	150.5	124.0	87.0	44.7	59.5	45.5
	0.4	62.7	119.8	165.0	192.0	198.0	178.0	150.5	107.2	55.5	64.0	56.0
	0.5	61.4	118.1	164.1	198.0	208.0	198.0	164.1	118.1	61.4	62.5	62.5
	0.6	55.5	107.2	150.5	178.0	198.0	192.0	165.0	119.8	62.7	56.0	64.0
	0.7	44.7	87.0	124.0	150.5	164.1	165.0	147.5	109.1	57.9	45.5	59.5
	0.8	31.6	61.4	87.0	107.2	118.1	119.8	109.1	85.7	46.4	32.0	48.0
	0.9	16.3	31.6	44.7	55.5	61.4	62.7	57.9	46.4	27.0	16.5	28.5
Triangle		$10^4\Delta_t$ (in.) for C_t on right									$10^3\theta_{Lt}$	$10^3\theta_{Rt}$
X′	0.1	8.1	15.3	20.9	24.7	25.9	25.0	21.1	15.4	8.1	8.1	8.3
	0.2	15.3	29.7	41.1	48.5	51.1	49.4	42.0	30.7	16.2	15.3	16.6
	0.3	20.9	41.1	59.0	70.0	74.1	72.0	62.0	45.0	23.6	20.9	24.4
	0.4	24.7	48.5	70.0	86.0	94.0	89.0	78.5	57.8	30.5	24.7	31.0
	0.5	25.9	51.1	74.1	94.0	104.0	104.0	90.0	67.0	35.5	25.9	36.6
	0.6	25.0	49.4	72.0	89.0	104.0	106.0	95.0	71.3	38.0	25.0	39.3
	0.7	21.1	42.0	62.0	78.5	90.0	95.0	88.5	68.0	37.0	21.1	38.6
	0.8	15.4	30.7	45 0	57.8	67.0	71.3	68.0	56.0	31.1	15.4	32.7
	0.9	8.1	16.2	23.6	30.5	35.5	38.0	37.0	31.1	18.9	8.15	20.4
Reversed Triangle		Linear, $10^4\Delta_t'$ (in.) for C_t' on left									Angular (radian)	
X″		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	$10^3\theta_{Lt}'$	$10^3\theta_{Rt}'$
X′	0.1	18.9	31.1	37.0	38.0	35.5	30.5	23.6	16.2	8.1	20.4	8.1
	0.2	31.1	56.0	68.0	71.3	67.0	57.8	45.0	30.7	15.4	32.7	15.4
	0.3	37.0	68.0	88.5	95.0	90.0	78.5	62.0	42.0	21.1	38.6	21.1
	0.4	38.0	71.3	95.0	106.0	104.0	89.0	72.0	49.4	25.0	39.3	25.0
	0.5	35.5	67.0	90.0	104.0	104.0	94.0	74.1	51.1	25.9	36.6	25.9
	0.6	30.5	57.8	78.5	89.0	94.0	86.0	70.0	48.5	24.7	31.0	24.7
	0.7	23.6	45.0	62.0	72.0	74.1	70.0	59.0	41.1	20.9	24.4	20.9
	0.8	16.2	30.7	42.0	49.4	51.1	48.5	41.1	29.7	15.3	16.6	15.3
	0.9	8.1	15.4	21.1	25.0	25.9	24.7	20.9	15.3	8.1	8.3	8.1
Sine Curve		$10^4\Delta_s$ (in.)									$10^3\theta_{Ls}$	$10^3\theta_{Rs}$
X′	0.1	18.4	34.3	45.5	51.0	52.1	47.0	36.8	25.4	12.9	18.4	12.9
	0.2	34.3	65.2	88.2	100.0	100.4	90.7	73.5	51.4	25.4	34.3	25.4
	0.3	45.5	88.2	120.0	137.5	141.0	128.0	104.0	73.5	36.8	45.5	36.8
	0.4	51.0	100.0	137.5	166.0	172.0	158.0	128.0	90.7	47.0	51.0	47.0
	0.5	52.1	100.4	141.0	172.0	182.0	172.0	141.0	100.4	52.1	52.1	52.1
	0.6	47.0	90.7	128.0	158.0	172.0	166.0	137.5	100.0	51.0	47.0	51.0
	0.7	36.8	73.5	104.0	128.0	141.0	137.5	120.0	88.2	45.5	36.8	45.5
	0.8	25.4	51.4	73.5	90.7	100.4	100.0	88.2	65.2	34.3	25.4	34.3
	0.9	12.9	25.4	36.8	47.0	52.1	51.0	45.5	34.3	18.4	12.9	18.4
X″		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9		

Unit Diagram



Working Equations

$$\Delta = \frac{PL^3}{E}(C_r\Delta_r + C_t\Delta_t - C_s\Delta_s) \qquad (1)$$

$$\theta_L = \frac{PL^2}{E}(C_r\theta_{Lr} + C_t\theta_{Lt} - C_s\theta_{Ls}) \qquad (2)$$

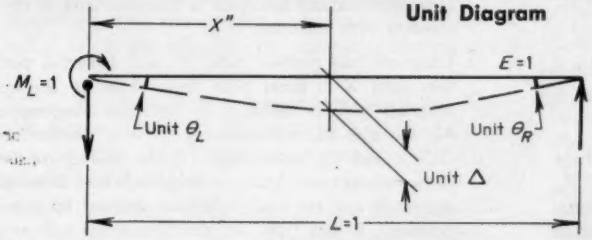
Similarly for θ_R

Table 2—Beam with Couples at Left End†

Four Shapes	Linear, $10^3\,\Delta_i$ (in.)									Angular (radian)	
X''	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	θ_{Li}	θ_{Ri}
C_r	28.5	48.0	59.5	64.0	62.5	56.0	45.5	32.0	16.5	0.333	0.167
C_t	8.1	15.3	20.9	24.7	25.9	25.0	21.1	15.4	8.15	0.083	0.083
C_t'	20.4	32.7	38.6	39.3	36.6	31.0	24.4	16.6	8.35	0.250	0.083
C_s	18.4	34.3	45.5	51.0	52.1	47.0	36.8	25.4	12.9	0.191	0.123

†Reorientation of the tabular values is necessary to apply them to couples at the right end. A simple way to do this is to think of unit couple M_R as replacing M_L at the left end of the unit diagram and then to select angular values according to C_t in the usual manner. This way is illustrated in Table 5 for Example 5. Another way is to use Working Equation 4 with the term to the left of the equals sign denoted by θ_R instead of θ_L. A third way is to prepare another table expressly for a beam with couples at the right end and from which tabular values can be read directly. This is achieved readily by rearrangement of the values already in Table 2.

Unit Diagram



Working Equations

$$\Delta = \frac{M_L L^2}{E}\,(C_r\Delta_r + C_t\Delta_t - C_s\Delta_s) \qquad (3)$$

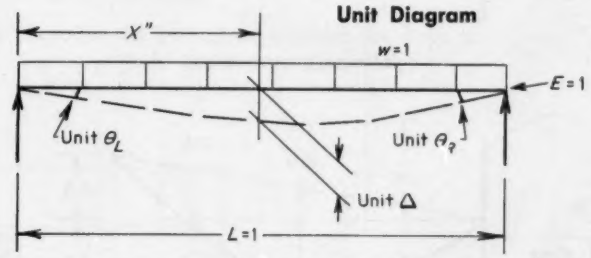
$$\theta_L = \frac{M_L L}{E}\,(C_r\theta_{Lr} + C_t\theta_{Lt} - C_s\theta_{Ls}) \qquad (4)$$

Similarly for θ_R

Table 3—Simple Beam with Uniformly Distributed Load

Four Shapes	Linear, $10^4\Delta_i$ (in.)									Angular (radian)	
X''	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	θ_{Li}	θ_{Ri}
C_r	41.0	77.0	106.0	122.0	130.0	122.0	106.0	77.0	41.0	0.0413	0.0413
C_t	16.5	32.4	46.8	57.9	65.0	64.1	59.2	44.6	24.5	0.0165	0.0248
C_t'	24.5	44.6	59.2	64.1	65.0	57.9	46.8	32.4	16.5	0.0248	0.0165
C_s	32.5	63.3	87.5	105.0	111.4	105.0	87.5	63.3	32.5	0.0325	0.0325

Unit Diagram



Working Equations

$$\Delta = \frac{wL^4}{E}\,(C_r\Delta_r + C_t\Delta_t - C_s\Delta_s) \qquad (5)$$

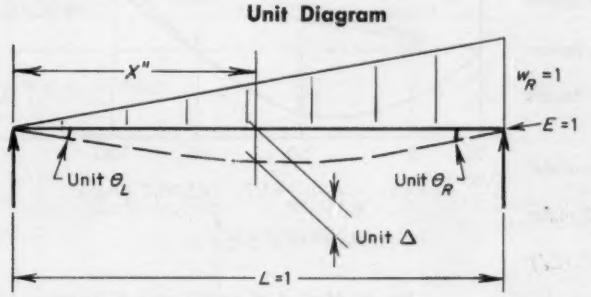
$$\theta_L = \frac{wL^3}{E}\,(C_r\theta_{Lr} + C_t\theta_{Lt} - C_s\theta_{Ls}) \qquad (6)$$

Similarly for θ_R

Table 4—Simple Beam with Linear Variation of Distributed Load (Triangular Load)

Four Shapes	Linear, $10^4\Delta_i$ (in.)									Angular (radian)	
X''	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	θ_{Li}	θ_{Ri}
C_r	19.0	36.2	51.0	60.0	65.0	62.0	55.0	40.8	21.0	0.0195	0.0221
C_t	8.3	16.3	23.7	29.6	33.6	34.3	31.2	24.1	13.3	0.0083	0.0137
C_t'	10.7	19.9	27.3	30.4	31.4	27.7	23.8	16.7	7.7	0.0112	0.0077
C_s	15.6	30.5	42.6	51.8	55.7	53.2	44.9	32.8	16.9	0.0156	0.0169

Unit Diagram



Working Equations

$$\Delta = \frac{w_R L^4}{E}\,(C_r\Delta_r + C_t\Delta_t - C_s\Delta_s) \qquad (7)$$

$$\theta_L = \frac{w_R L^3}{E}\,(C_r\theta_{Lr} + C_t\theta_{Lt} - C_s\theta_{Ls}) \qquad (8)$$

Similarly for θ_R

gram in which a concentrated unit load P of 1 lb acts on a beam of unit length.

Tables 1, 2, 3, and 4 list deflections for unit distribution of C_r, C_t, and C_s under various types of unit loading. Any total deflection Δ of a beam consists of the algebraic sum of three, two-term products multiplied by a proportionality factor. This factor depends upon beam dimensions, material, and loading. It serves to amplify the ratios into definite magnitudes pertinent to a particular beam of specified length and loading. Working equations and a unit diagram below each set of tabular values identify the components, as well as indicate the mathematical operation in applying them to get deflections.

Outline of the Method: Examples illustrate the details of finding deflections. General steps in the application of the method are

1. Plot the C diagram for the given beam or machine part, Fig. 2*b*. Five points—the two ends, 0.2L, 0.5L, and 0.8L—give sufficient accuracy for most problems. The accuracy attainable from this method depends upon the accuracy of plotting the C diagram and also upon the closeness with which the combination of zone diagrams approximate the plot. The half-sine area, for example, provides good fit when the sections vary gradually as well as continuously. For more abrupt, yet continuous, variation in C values, some other curve may yield a better fit. How the tabular values are established is explained in the next section.
2. Separate the C diagram into zones as indicated in Fig. 1.
3. Modify the C diagram for good fit of the sine curve and the C plot, if necessary. Often the accuracy requirements of a problem do not warrant refinements in calculations; C_r, C_t, and C_s can be used directly. How modifications are made is discussed later in conjunction with examples.
4. Designate load position ratio, X', and deflection position ratio X''. Enter with these ratios in the appropriate table, or tables, to get deflection components, Δ_r, Δ_t, and Δ_s, corresponding to unit distributions C_r, C_t, and C_s, respectively. If the loading consists of two concentrated loads, or more, each load is treated separately and the total deflection obtained by superposition. If two types act simultaneously, such as a

Nomenclature

C = Reciprocal of moment of inertia, in.$^{-4}$
C_r = Ordinate of the rectangular zone of a C diagram
C_s = Maximum ordinate of sine function zone of a C diagram
C_t, C_t' = Maximum ordinate of triangle zone of C diagram
d = Diameter, in.
E = Modulus of elasticity, psi
I = Moment of inertia, in.^{4}
L = Length of beam or machine part, in.
M = Bending moment, in.-lb
M_L = Bending moment at left end, in.-lb
M_R = Bending moment at right end, in.-lb
P = Concentrated load, lb
w = Constant load per unit of length, lb per in.
x = Variable distance along axis, in.
X' = Ratio of position of concentrated load along beam and length of beam
X'' = Ratio of position at which deflection is sought and length of beam
α = Angular slope of arched beam
θ = Angular deflection of beam or slope, radian
θ_L, θ_R = Angular deflection of beam at left (right) end, radian
θ_{Lr}, θ_{Rr} = Left-end (right-end) rotational deflection factors from table for unit C_r under unit load.
θ_{Ls}, θ_{Rs} = Left-end (right-end) rotational deflection factors from table for unit C_s under unit load.
θ_{Lt}, θ_{Rt} = Left-end (right-end) rotational deflection factors from table for unit C_t under unit load.
$\theta_{Lt}', \theta_{Rt}'$ = Left-end (right-end) rotational deflection factors from table for unit C_t' under unit load.
Δ = Total linear deflection, in.
Δ_r = Deflection factor from table for unit C_r under unit load
Δ_s = Deflection factor from table for unit C_s under unit load
Δ_t, Δ_t' = Deflection factor from table for unit $C_t(C_t')$ under unit load.

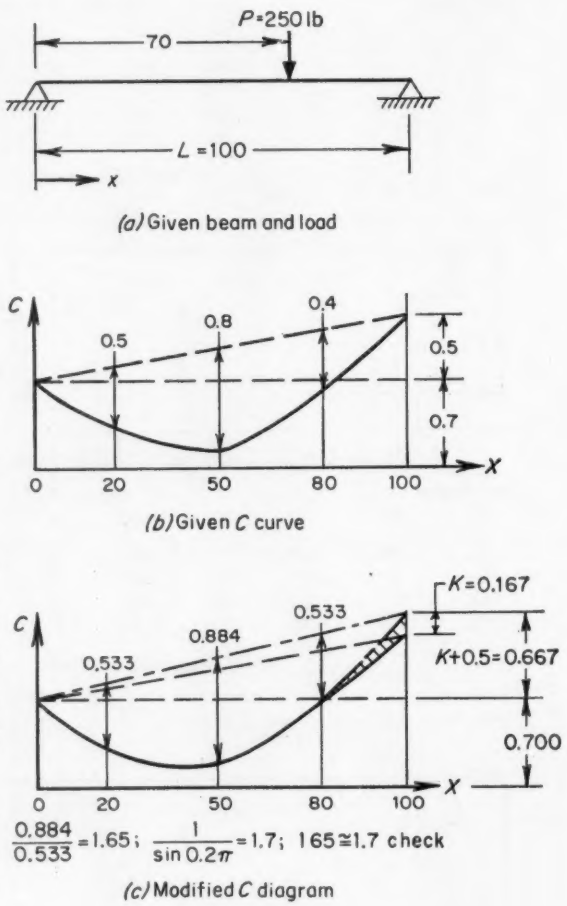


Fig. 2—Method of modifying a C diagram.

concentrated load and a uniformly distributed load, again each is treated separately, different tables are used to suit the basic types, and the total deflection is found by superposition.

5. Determine the three partial products of the form $C\Delta$, add them together, and multiply the sum by the proportionality factor as called for by a working equation. As shown in Fig. 1, C_s is usually negative so that the partial products $C_s\ \Delta_s$ are subtractive in the working equations.

Tabular Values and Their Calculation: The "reversed triangle" section of Table 1 contains the same magnitudes as the C_t section. The magnitudes are rearranged so that the defining ordinate of the triangle, C_t', is on the left, Fig. 1*d*, instead of the right, Fig. 1*c*.

The C_t' magnitudes are convenient when the C diagram slopes downward to the right instead of upward as in Fig. 1*a*. They merely replace the C_t magnitudes in calculations.

A more important advantage of the C_t' magnitudes is realized when end moments make up the loading, Table 2, and when triangle loading occurs, Table 4. These tables contain fewer entries than Table 1 simply because the types of loading admit less variety than concentrated loads. Preparation of a set of values for a table is a mathematical chore—tedious perhaps but not difficult. The initial step is a choice of curve, such as a sine curve, or a triangle, to define a zone of the C diagram. Next, a type of loading is selected.

To illustrate the procedure, consider the steps in verifying the deflection factor Δ at $X'' = 0.5$ for the unit sine curve distribution, C_s, under uniform loading. The conjugate beam* method is applied to the unit diagram in Table 3, resulting in the steps of analysis in Fig. 3.

In the conjugate beam method, the conjugate beam, Fig. 3*e*, is subjected to a distributed load such that the intensity of the load at any section is proportional to the ordinate of the MC/E diagram of the given beam at that section. The given beam and the conjugate beam are made equal in length; hence, the deflection of the given beam at any section is equivalent to the calculated bending moment of the conjugate beam.

Reactions R_L and R_R of the conjugate beam, Fig. 3*e*, are found by statics. From them and loading MC/E, the shear and bending moment diagrams of the conjugate beam can be constructed. The shear diagram gives the plot of beam slope with span position and the moment diagram gives the vertical deflection with span position.

In integral form, the reactions for the conjugate beam are expressed by

$$R_L = R_R = \frac{1}{2}\int_0^1 \frac{MC}{E}\,dx$$

and the deflection at midspan (which is the bending moment of the conjugate beam) by

$$\Delta = 0.5\,R_L - \int_0^{1/2} \frac{MC}{E}\,(0.5 - x)\,dx$$

*F. B. Seely—*Resistance of Materials*, John Wiley & Sons Inc., New York, First Edition 1925, Third Edition 1947.

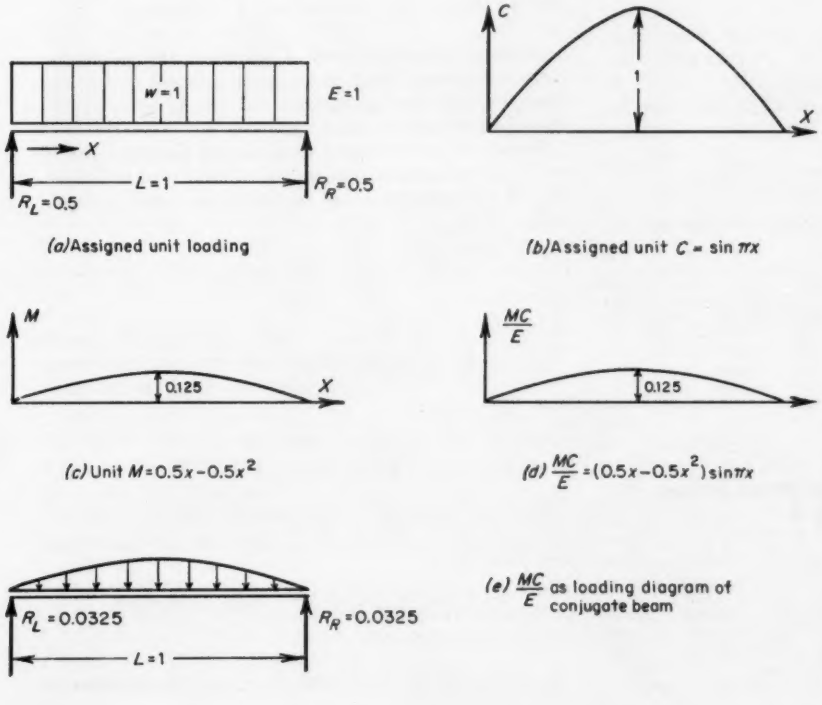


Fig. 3 — Solving deflection factors for a unit diagram by the conjugate beam method.

A numerical integration can be employed to get the values of Table 3. If increments of dx (or Δx) are taken at intervals of one-tenth span, the numerical values become sums of the form

$$R_L = R_R = \frac{1}{2} \sum \frac{MC}{E} \Delta x$$

Tables 1, 2, 3, and 4 were calculated by analytic integrations, then checked with closely spaced numerical integrations. While the differences in values obtained from the two methods were small, generally within 4 per cent, a few differed by as much as 7 per cent.

Within this degree of reliability, therefore, the convenience of numerical integration can be used to construct additional reference tables. (The examples that follow were solved with tables prepared by numerical integration; hence, some of the numerical values vary slightly from those in the reference tables published now.)

A useful constant that applies to Fig. 2c and 3c is 1.70, which is the ratio of the C value at $x = 0.5$ to that at $x = 0.2$ for the sine function. This constant is used frequently in verifying the fit of the sine curve to the plotted C curve.

EXAMPLE 1, BEAM OF UNIFORM SECTION: A 3-in., 5.7-lb steel I-beam, 38 in. between supports carries a concentrated load of 750 lb, 13 in. from the right support. Find the deflection 15 in. from the left support.

Since the section is constant, only C_r applies; $C_r = 1/I = 1/2.5 = 0.400$. The load position ratio $X' = 25/38 = 0.658$, the deflection position ratio $X'' = 0.395$, and $\Delta_r = 161.2 \times 10^{-4}$, by linear interpolation in Table 1. When the known quantities are put into Equation 1,

$$\Delta = \frac{PL^3}{E} (0.400)(161.2)10^{-4} = 0.0085 \text{ in.}$$

EXAMPLE 2, BEAM OF VARYING SECTION: Fig. 2*b* is a typical C diagram of a simple beam with a concentrated load, P. If this beam is aluminum alloy with $E = 10 \times 10^6$ psi, find the deflection in the plane 40 in. from the left support.

Table 5—Given and Calculated Values for Example 4

x/L	x	$\sin \alpha\, x/r$	α, deg	$\sec \alpha$	I	$C = \sec \alpha / I$
0	0	0	0	1.0	0.100	10.0
0.2	2	0.142	8.2	1.01	0.092	11.0
0.5	5	0.356	20.8	1.06	0.079	13.4
0.8	8	0.570	35.0	1.22	0.065	18.8
1.0	10	0.710	45.0	1.41	0.055	25.6

Table 6—Given and Calculated Values for Example 5

1. x/L	2. x	3. h	4. h^3	5. I	6. $C=1/I$	7. $C-0.63$	8. y/L	9. $1.87y/L$	10. (9)—(7)
0	0	2.0	4	0.40	2.50	1.87	1.0	1.870	0
0.2	9	2.4	5.8	0.58	1.73	1.10	0.8	1.496	0.396
0.5	22.5	3.0	9	0.90	1.10	0.47	0.5	0.935	0.465
0.8	36	3.6	13	1.3	0.77	0.14	0.2	0.374	0.234
1.0	45	4.0	16	1.6	0.63	0	0	0	0

The C_s component is not an exact sine curve because the offsets of 0.5 and 0.4 are unequal. These inequalities are balanced by adding a small area as indicated by the crosshatching, Fig. 2c.

This area is added at the end with the larger C. In some examples, the area must be subtracted. Adjustment of the sine curve to fit the C curve as closely as possible is a refinement, which may or may not be regarded as worth the effort. The error introduced by altering the C diagram is also small since the modification extends over only a fraction of the span.

To balance the sine curve the ordinates at $x = 0.2L$ and $0.8L$ are used. By proportion

$$0.2K + 0.5 = 0.8K + 0.4$$

Therefore, $K = 0.167$ and the numerical values of the ordinates as stated on Fig. 2c are obtained. The $C_r = 0.700$ is unmodified but $C_t = 0.667$ and $C_s = 0.884$ after modification.

The load position ratio is $X' = 0.700$; the deflection position ratio is $X'' = 0.400$. From these values and Table 1, $\Delta_r = 150.0 \times 10^{-4}$, $\Delta_t = 81.0 \times 10^{-4}$, and $\Delta_s = 131.0 \times 10^{-4}$. Thus,

$$C_r\Delta_r + C_t\Delta_t - C_s\Delta_s = (0.700 \times 150.0 +$$

$$0.667 \times 81.0 - 0.884 \times 131.0)10^{-4} = 43.0 \times 10^{-4}$$

When these values are put into Equation 1,

$$\Delta = \frac{PL^3}{E} (43.0 \times 10^{-4})$$

$$= \frac{250 \times 10^6}{10 \times 10^6} (43.0 \times 10^{-4}) = 0.107 \text{ in.}$$

If the original ordinates of the triangle and sine curve, that is, $C_t = 0.50$ and $C_s = 0.80$, are used in Equation 1 rather than the modified values, $\Delta = 0.102$ in. Whether the difference between the 0.102 without modification and the 0.107 with it warrants the extra effort to make the calculations depends on circumstances of the problem.

EXAMPLE 3, TAPERED SHAFT: A steel shaft has the dimensions, concentrated load, and supports indicated by Fig. 4*a*. Find the deflections at midspan and in the plane 12 in. from the left support.

Because of the symmetry of shaft and loading, there is no triangle component; only half the C curve need be plotted, Fig. 4*b*. By proportion and the use of sine curve constant, 1.70,

$$\frac{C_r - 0.05}{C_r - 0.202} = 1.70$$

to give $C_r = 0.42$. Thus, $C_s = 0.42 - 0.05 = 0.37$. Dashed lines, Fig. 4*b*, define the rectangle and sine curve components of half the C diagram. The proportionality factor in Equation 1 is

$$\frac{PL^3}{E} = \frac{7500(40)^3}{30 \times 10^6} = 16$$

From Table 1 with $X'' = 0.5$ and $X' = 0.5$, $\Delta_r = 207.0 \times 10^{-4}$, and $\Delta_s = 184.0 \times 10^{-4}$. When these values are put into Equation 1,

$$\Delta = 16[0.42(207.0)10^{-4} - 0.37(184.0)10^{-4}]$$

$$= 0.030$$

Similarly, with $X' = 0.5$ and $X'' = 0.3$, the deflection at

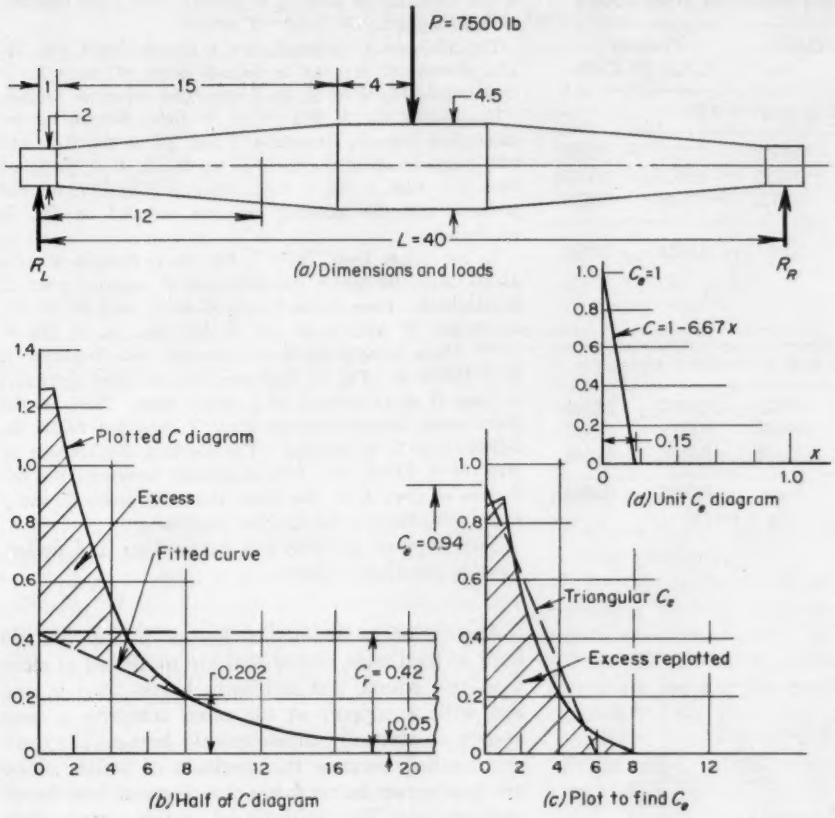


Fig. 4—Tapered shaft of Example 3.

Fig. 5 — Below — Arc-shaped lever of Example 4.

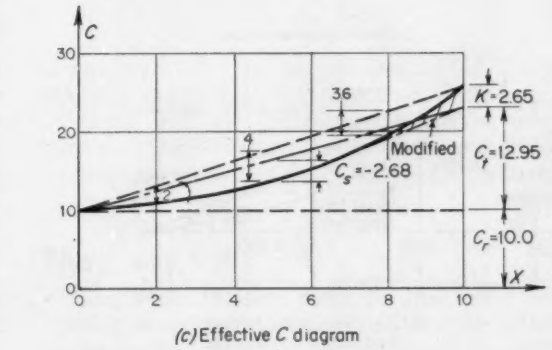
12 in. from the left end is $\Delta = 0.024$ in.

Obviously, the fitted curve and the C diagram fail to match by a sizable area at the ends of the shaft, Fig. 4*b*. Although this method is less sensitive to mismatch at the ends than elsewhere, one may reasonably ask: How big is the error in this example?

Crosshatching indicates the excess area, Fig. 4*b*. An advantage of the triangle zone is its adaptability in approximating such areas. In Fig. 4*c*, the excess is replotted and then approximated by the dash-line triangle, which fixes ordinate $C_e = 0.94$. The position along the beam is $6/40 = 0.15$, to correspond to unit diagram Fig. 4*d*. These magnitudes provide a correction to the foregoing unmodified values of 0.0038, say 0.004. Thus, deflections of 0.034 in. at midspan and 0.028 in. at 12-in. from the left support represent the results of calculations with modifications.

Application of the unit C_e diagram illustrated by Fig. 4d is general whenever the correction of large errors at the ends seems necessary. Other conditions that may help to indicate when to consider this type of correction are beams and machine parts with loads near the reactions and with end-couple loads.

EXAMPLE 4, DEFLECTIONS IN CURVED LEVER: An arc-shaped control lever has the dimensions and loads defined by Fig. 5, Table 5, and $I = 0.10 - 0.01\,\alpha$, where I is the moment of inertia of a section perpendicular to the arc. If the lever is aluminum alloy with $E = 10 \times 10^6$, find the magnitude



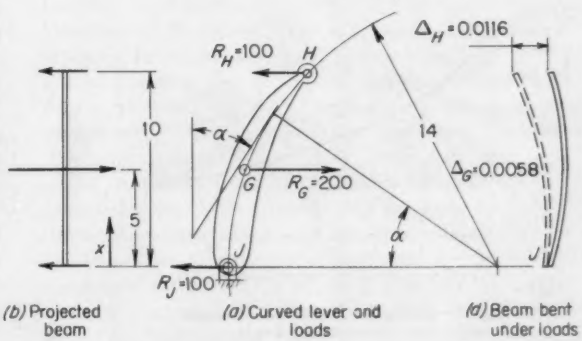
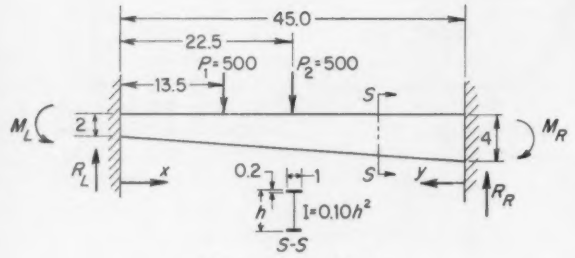
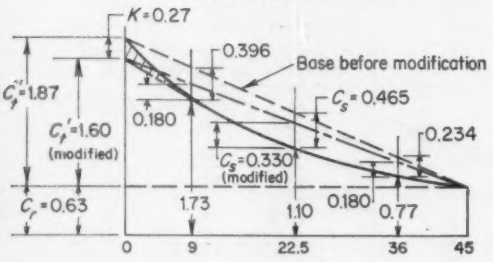


Table 7—Example 5 End Rotations from Loads

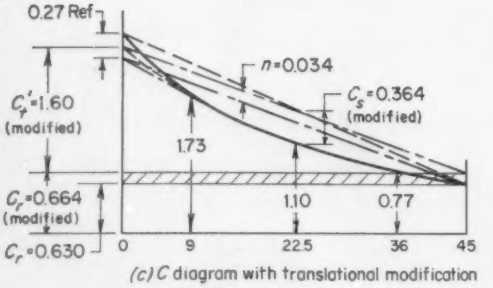
Component Symbol	Component Magnitude	From Table 1 θ_{Li}	From Table 1 θ_{Ri}	Products $C_i\theta_{Li}$	Products $C_i\theta_{Ri}$
	Load $P_1 = 500$ lb at $X' = 0.30$				
C_r	0.630	0.0595	0.0455	0.0375	0.0286
C_t'	1.60	0.0377	0.0215	0.0605	0.0345
C_s	−0.330	0.0445	0.0375	−0.0146	−0.0124
Equation 2			Sum	0.0834	0.0507
$A = PL^2 = 500(45)^2 \approx 10^6$					
$E\theta_L = A\,(0.0834) = 83{,}400$					
$E\theta_R = A\,(0.0507) = 50{,}700$					
	Load $P_2 = 500$ lb at $X' = 0.50$				
C_r	0.630	0.0625	0.0625	0.0395	0.0395
C_t'	1.60	0.0360	0.0261	0.0575	0.0417
C_s	−0.330	0.0510	0.0510	−0.0168	−0.0168
Equation 2			Sum	0.0802	0.0644
$E\theta_L = 80{,}200$			$E\theta_R = 64{,}400$		



(a) Given beam and loads



(b) C diagram with rotational modifications to equalize offsets



(c) C diagram with translational modification

Fig. 6—Redundant beam of Example 5 with two concentrated loads.

of the deflection of pivot H if pivots G and J are regarded as beam supports.

The arc-beam is projected into a straight beam, Fig. 5*b*. The effective C diagram is defined by $C = \sec \alpha/I$. It is plotted in Fig. 5*c* to fit the five-position values of Table 5.

Unmodified, $C_t = 25.6 - 10 = 15.6$. Relative to the unmodified triangle, departures 2 and 3.6 at the $0.2L$ and $0.8L$ positions along the C-curve are found; K is computed from $2 - 0.2K = 3.6 - 0.8K$, which is subtractive for this problem; and the modified ordinates recorded on Fig. 5*c* are found.

To get values from Table 1, Fig. 5*b* is thought of as a simple beam for which the deflection of midspan pivot G is calculated. From Table 1 with $X' = 0.5$ and $X'' = 0.5$, $\Delta_r = 207 \times 10^{-4}$, $\Delta_t = 104 \times 10^{-4}$, and $\Delta_s = 184 \times 10^{-4}$. Upon substituting these quantities into Equation 1, $\Delta = 0.0058$ in. Fig. 5*d* illustrates this calculated deflection of pivot G as an ordinate of a simple beam. Now, let the beam rotate counterclockwise about J until the 0.0058 in. deflection at G is nullified. The resulting displacement of pivot H is 0.0116 in. This magnitude represents the deflection of pivot H in the lever relative to pivots G and J as a consequence of the specified loading.

This type of analysis can be used to find deflections in cantilever beams.

Application to Redundant Beams: Beams that are fixed at both ends, beams that are supported at more than two points, and cantilever beams fixed at one end with a support at the other comprise a class known as statically indeterminate beams. They are so classified because the methods of statics alone are inadequate in resolving the reactions into forces and couples. The methods of statics supply only two equations involving the equilibrium of the reactions. Statically indeterminate beams have more than two reactions to be determined. Elastic action provides the additional equations needed.

Those in excess of two are regarded as redundant. For example, a beam fixed at both ends has two supporting forces and two end couples or moments, the couples being the redundants. The deflections of such a beam are much less than those of an equivalent simple beam under the same loading. In general, an equation for a redundant beam is obtained by establishing the conditions that make either an end rotation zero or some intermediate Δ deflection is restrained to be zero. When couples exist at both ends, they supply two equations in two unknowns, which can be solved simultaneously.

Machine parts are redundant in untold numbers—shafts with more than two supports, castings of varying sections between fixed flanges. Often the reactions on redundant members are rarely calculated because of the complexity of carrying out the calculations. The tables here should reduce both the complexity and the drudgery of finding reactions. An example sets forth the application of the tables.

EXAMPLE 5, BEAM FIXED AT BOTH ENDS: Consider a tapered I-beam carrying two concentrated loads, Fig. 6*a*. Find the end couples M_R and M_L.

C Diagram: Column 6 of Table 6 lists the calculated points of the C diagram, Fig. 6*b*. Columns 8, 9, and 10 contain the calculations to obtain the ordinates of the sine curve

Table 8—Unit End Rotations for Example 5

M_L, Left End, Table 2				Components		M_R, Right End, Table 2			
θ_{Li}	θ_{Ri}	Products		Symbol	Magnitude	θ_{Li}	θ_{Ri}	Products	
0.333	0.167	0.209	0.105	C_r	0.630	0.333	0.167	0.209	0.105
0.250	0.083	0.400	0.133	C_t', C_t	1.60	0.083	0.083	0.133	0.133
0.191	0.123	−0.062	−0.040	C_e	−0.330	0.191	0.123	−0.062	−0.040
		0.547	0.198	Sum				0.280	0.198
$A = M_L L = 1 \times 45 = 45$									
$E\theta_L = A(0.547) = 24.5$				Influence		$E\theta_L = A(0.280) = 12.6$			
$E\theta_R = A(0.198) = 8.87$				coefficients		$E\theta_R = A(0.198) = 8.87$			

NOTE: In columns M_R and M_L, duplicate entries of C_r and C_e and their products are made to orient the reciprocal nature of the values of C_t' and C_t as taken from Table 2. Specifically, C_t applies to M_R and C_t' applies to M_L. Furthermore, two influence coefficients, one from each pair, are always equal. In this problem, they are $E\theta_R$=8.87. (See footnote to Table 2.)

of the unmodified diagram. Modification factor K is found from $0.396 - 0.8K = 0.234 - 0.2K$, a relationship established by proportionate distances between the sides of a triangle.

Ordinates of the sine-curve area, after modification, are indicated on Fig. 6*b*. To check the fit of the curve, 0.330/0.180 = 1.83 which is sufficiently near 1.70 to mean a good fit. Thus, the C diagram ordinates carried forward in the solution of the problem are $C_r = 0.63$, $C_t' = 1.60$ and $C_e = 0.330$.

End Rotations Due to Loads: Each load is treated separately. For load P_1, the position ratio is $X' = 13.5/45 = 0.3$. This ratio is entered into Table 1 to find the values listed in the second and third columns of the top half of Table 7. From them, the other tabular values pertinent to load P_1 are calculated, after which Equation 2 is used to find $E\theta$ magnitudes.

Position ratio for load P_2 is $X' = 22.5/45 = 0.5$. When this X' is handled in the same manner as that for load P_1, the magnitudes listed in the bottom half of Table 7 are obtained.

End Rotations Due to Unit Values: Table 2 applies when end couples have unit values of one lb-in. at the left end. It is used to find the rotational deflection factors, θ_{Li} and θ_{Ri}, recorded in Table 8. The associated products are formed and Equation 4 is solved for $E\theta$ values.

The resultant left-end rotational deflection is zero. Thus, for clockwise rotation positive,

$$-24.5\,M_L - 8.87\,M_R + 83{,}400 + 80{,}200 = 0$$

Likewise, the resultant right-end rotational deflection is zero so that

$$8.87\,M_L + 12.6\,M_R - 50{,}700 - 64{,}400 = 0$$

When these equations are solved simultaneously, M_R = 5900 lb-in. and M_L = 4600 lb-in.

Are Modifications Worthwhile? Much might be said for and against the extra accuracy realized from modifications. If 0.004 in 0.024 is judged significant, as illustrated by Example 3, then corrections should be calculated. If order of magnitude only is significant, calculations are simpler and quicker without the modifications.

Example 3 is representative of problems where the C values increase sharply at the ends. The C_e values (left and right) reflect these increases. When applied, as in Fig. 4*d*, corrections to Δ, θ_L, and θ_R are readily obtained.

Perhaps it should be emphasized that the corresponding working equations are functions of total static reactions R_L and R_R as well as end moments. Thus, for combined loadings on a beam, the total resulting R_L and R_R are applied in the correction equation only once. For redundant problems, the correction has to be applied once for each redundant. Furthermore, all influence coefficients are affected by a C_e correction. Fig. 6*c* illustrates a modification to C_r to provide a better fit of the sine curve than that given in Fig. 6*b*.

The relationship used to find correction n is

$$\frac{0.330 + n}{0.180 + n} = 1.70$$

to give n = 0.034. In this problem n is small and relatively unimportant, but that is not always so.

Practice with the method and qualitative judgment soon enable one to predict the need of modifications and corrections for specific design problems.

They say . . .

Today's manager must direct the activities of men working at widely separated points and for different companies—yet success depends upon the ability to work out differences as they arise between various members of the team. Group research should more properly be called co-operative research. The problem of the manager is to obtain group success in a field where the individual and his contribution are paramount. The art of clearly expressing instructions—of giving unmistakable directions, and the ability to report back the understanding of an instruction must be developed. One has only to glance through an instruction manual for a complex piece of equipment to understand the need for improved communications.—O. S. CARLISS, *Director of Engineering, Materials Handling Div., Yale and Towne Mfg. Co., Philadelphia, Pa.*

Properties of

Metals at Low Temperatures

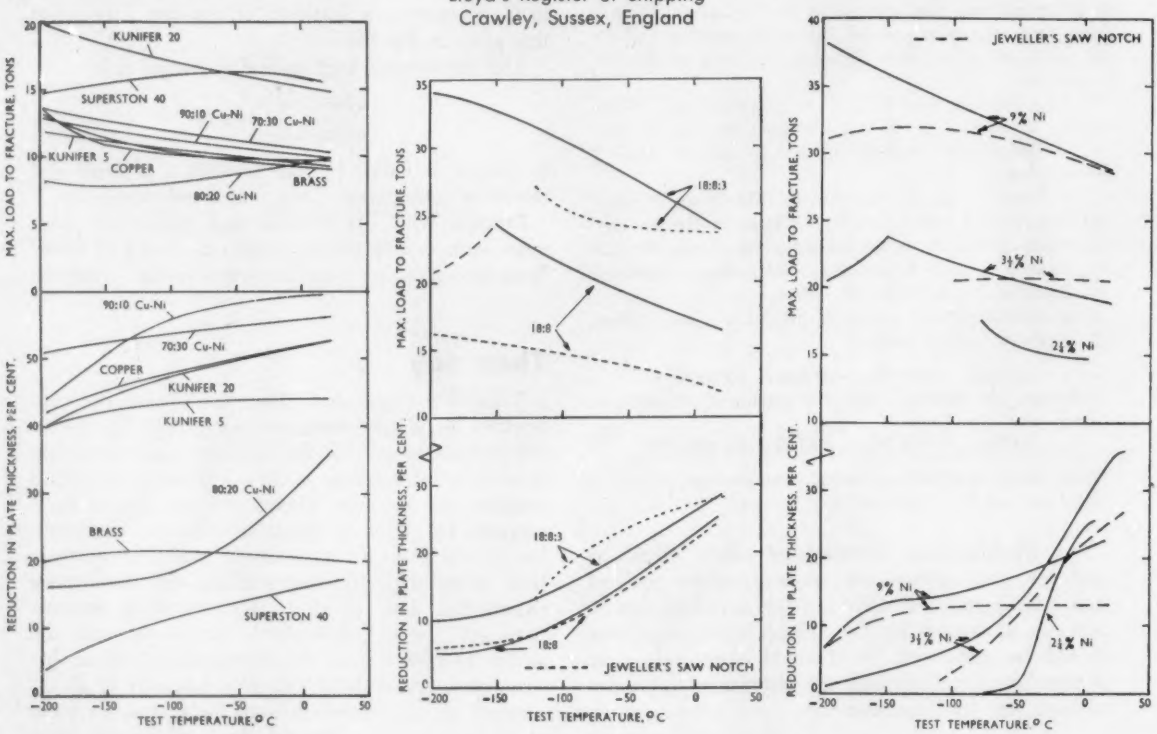
TO DEVELOP specific and factual data on the properties of base materials for low-temperature service, a program of laboratory testing at temperatures down to −196 C has been conducted on a number of metals and alloys. Results are available for four classes of wrought materials: 1. Copper and copper alloys. 2. Nickel alloys. 3. Austenitic stainless steels. 4. Low-carbon nickel steels.

The program consisted of U. S. Navy tear tests, plain and Tipper-notched tensile tests, and Charpy V-notched impact tests. Materials were plates ½ to ¾ in. thick.

Copper and Copper Alloys: These included samples of arsenical copper; 60:40 brass; cupro-nickel of 90:10, 80:20, and 70:30 compositions; Kunifer 5 (a 5 per cent nickel alloy containing iron and manganese); Kunifer 20 (a 20 per cent nickel alloy with iron and manganese); and Superston 40 (a manganese-aluminum bronze).

R. E. LISMER
Research Dept.
Lloyd's Register of Shipping
Crawley, Sussex, England

The results of the test program with these alloys are shown in Fig. 1*a*, 2, and 4. With the exception of the 80:20 cupro-nickel and Superston 40, the maximum load required to fracture the tear-test specimens increased a little with decrease of temperature, and the ductility slightly decreased. With the further exception of brass, the ductilities remained very high at −196 C. Superston 40 and 80:20 cupro-nickel showed a slight decrease in maxi-



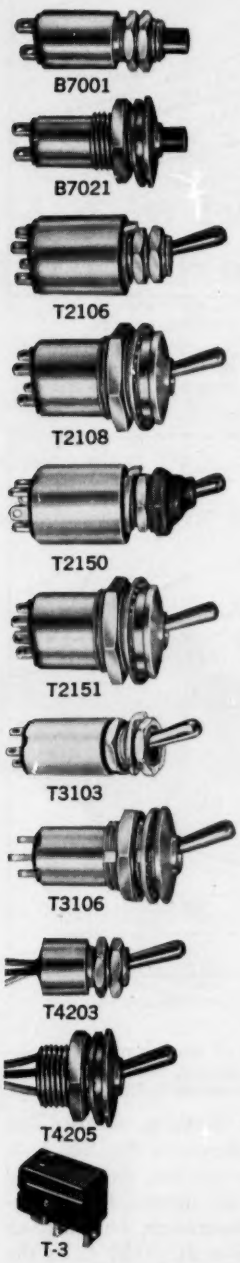
(a) Copper and copper alloys. (b) Austenitic stainless steels. (c) Nickel steels.

Fig. 1—Reduction in plate thickness and maximum load-to-fracture, according to US Navy tear tests.

ENGINEERING NEWS-#14

FULL LINE OF MINIATURE SNAP-ACTION SWITCHES

CHECKED	ENGR.	CONTROL SWITCH DIVISION



SPECIFICATIONS

Model No.	Amps @ 28 VDC or 120 VAC Resist	Induc.	Circuitry	Approx. Weight Lbs.
B7001	7	4	S.P.N.O.	.005
B7021	7	4	S.P.N.O.	.010
T2106	10	5	2 Cir.	.010
T2108	10	5	2 Cir.	.016
T2150	3	1	D.P.D.T.	.010
T2151	3	1	D.P.D.T.	.016
T3103	5	3	S.P.D.T.	.009
T3106	5	3	S.P.D.T.	.013
T4203	1	—	S.P.D.T.	.004
T4205	1	—	S.P.D.T.	.013
T-3	7.5	2.5	S.P.D.T.	1.6 Grams

NOTE: All models above (except T-3) are available with maintained or momentary action. Self-sealing boot available for any bushing mounted model, as shown on T2150. All models available with flange or bushing type mounting. Basic switch Model T-3 is available with a wide variety of standard and special actuators.

These miniature pushbutton and toggle switches are typical examples of our complete line of miniaturized switches. Whatever your requirements for miniature hand-operated or mechanically-operated switches, we can meet your needs from our hundreds of standard and custom units. We offer an almost unlimited range of variations in configuration, actuation, ratings, operating characteristics, etc.

For more technical information on switches and indicator lights, write for FREE CATALOG No. 100.

CONTROLS COMPANY OF AMERICA
CONTROL SWITCH DIVISION
1426 Delmar Drive • Folcroft, Pennsylvania
TELEPHONE LUdlow 3-2100 • TWX SHRN-H-502

Manufacturers of a full line of switches, controls and indicators for all military and commercial applications. All standard units stocked for immediate delivery by leading electronic parts Distributors.

COMPLETE LINE OF TOGGLE ACTUATORS ALSO AVAILABLE

You can virtually custom-design your own switch by using a basic switch case combined with any of the thousands of different actuator styles, sizes and characteristics. Here are just two examples.

TOGGLE . . . maintained, 2-pole, ¼"-40 bushing. Fits E4-series switches.

PUSHBUTTON... single pole, spring-loaded plunger, 15/32" bushing. Fits S-series switches.

Circle 490 on Page 19

mum load with decrease in temperature, but there was marked decrease in ductility, particularly in the case of Superston 40.

With the exception of the 80:20 cupro-nickel and Superston 40, values for the energy required to initiate and propagate fracture increased markedly with decrease of temperature. No changes in the nature of the fracture were observed.

Increase in severity of notch in the copper, brass, and Superston 40 materials produced only a slight decrease of maximum load and energies to initiate and propagate fracture.

The results of plain tensile tests showed a marked increase of strength with decrease of testing temperature for all the copper alloys. With the exception of Superston 40, changes in ductility at fracture involved an increase in the percentage elongation and a decrease in the percentage reduction of area. In general, the results of the notched tensile tests were in agreement with the results of the plain tensile tests.

The results of Charpy V-notched impact tests are:

1. Copper, 70:30 cupro-nickel, and Kunifer 5, having impact energies 100 ft-lb at ambient temperature, generally showed increases with decrease in temperature to −196 C.
2. 90:10 cupro-nickel and Kunifer 20, having impact energies between 60 and 70 ft-lb at ambient temperature, showed slight increases to optimum values at −150 C.
3. Brass, 80:20 cupro-nickel, and Superston 40, having impact energies between 30 and 45 ft-lb at ambient temperature, showed uniform, or decrease in, values with decrease of temperature to −196 C.

Nickel Alloys: Navy tear tests only were made on two wrought nickel alloys, Monel and Inconel. At room temperature, the values for maximum load are similar for both alloys, although Monel shows considerably higher total energy. Separate energies to initiate and propagate fracture, and the ductility of Monel, are considerably higher. With decrease of testing temperature:

1. Increase of the maximum load was progressive and slightly greater for Monel than for Inconel.
2. Increase of the total energy to fracture was marked, particularly for Monel.
3. Ductility slightly decreased, although at −196 C. Inconel showed a pronounced increase compared with that at −150 C.
4. Between −150 and −196 C, the fracture of Inconel changed from the single oblique shear characteristics to a fracture normal to the plate surface. Monel showed no change in the appearance of fracture down to −196 C.

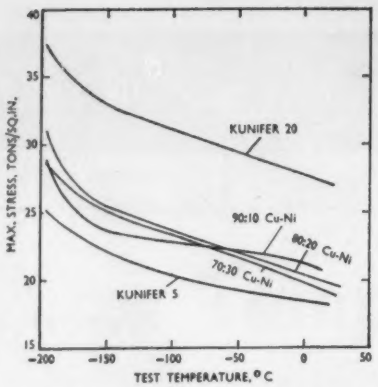


Fig. 2—Effect of temperature on tensile strength of copper and copper alloys.

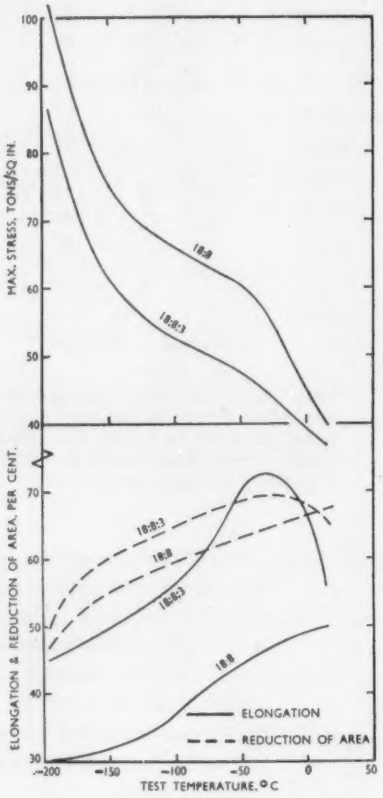


Fig. 3—Effect of temperature on tensile strength and reduction and elongation of area of austenitic stainless steels.

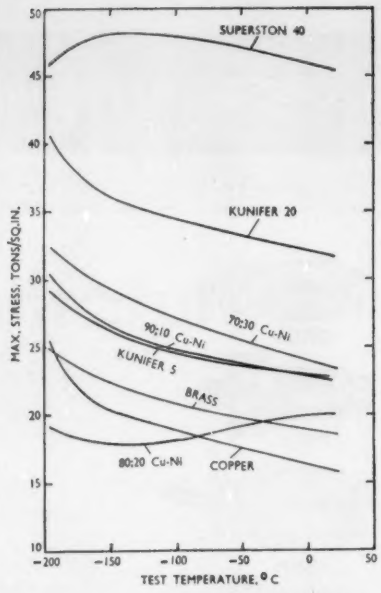


Fig. 4—Effect of temperature of Tippernotch tensile strength of copper and copper alloys.

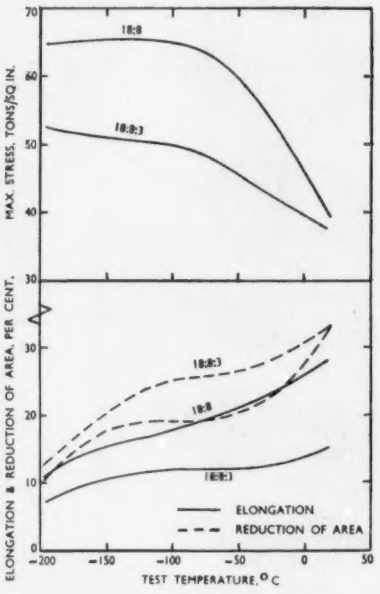
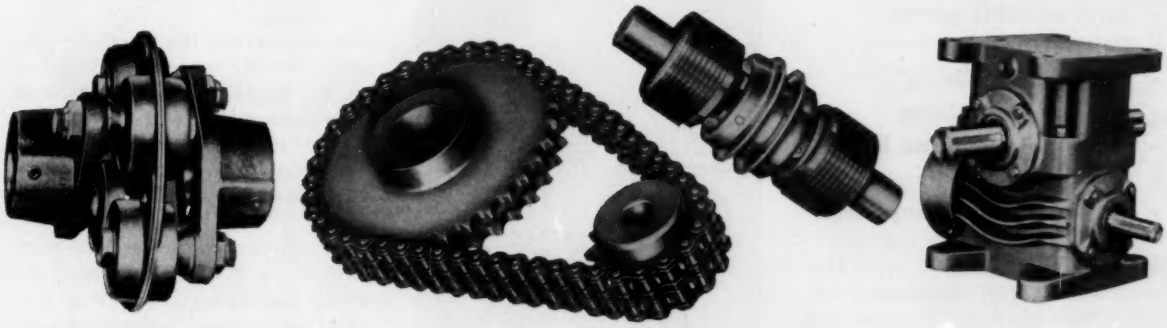


Fig. 5—Effect of temperature of Tippernotch tensile strength and reduction and elongation of austenitic stainless steels.

Austenitic Stainless Steels: Test results are shown in Fig. 1*b*, 3, 5, and 6. In the tear test, the maximum load-to-fracture increased with decrease of temperature, but with an optimum value at −150 C in the case of 18:8 plate. Increased sharpness of the root of the notch produced a marked reduction of the maximum load values, particularly at the lower temperatures of test. At the high values of maximum load obtained with these steels, the rate

Morse has an answer to every industrial drive problem under the sun

Basic Drives, Speed Reducers, Couplings, Clutches—only Morse makes all four and only Morse stocks all four. For example, if your industrial drive problem involves basic drives such as roller chain, silent chain, and Hy-Vo® Drives, or "Timing"® belts, friction clutches, and couplings, too, look to Morse for the answer. You'll get impartial engineering help and immediate delivery.



As for quality, Morse products speak for themselves: Morse timing chain is original equipment in over 76% of American cars. So whatever your industrial drive problem, see your Morse man. He's in the Yellow Pages. Or write: Morse Chain Co., Dept. 6-31, Ithaca, N.Y. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.

MORSE

A BORG-WARNER INDUSTRY

BW

There's an R/M friction part in every make automatic transmission

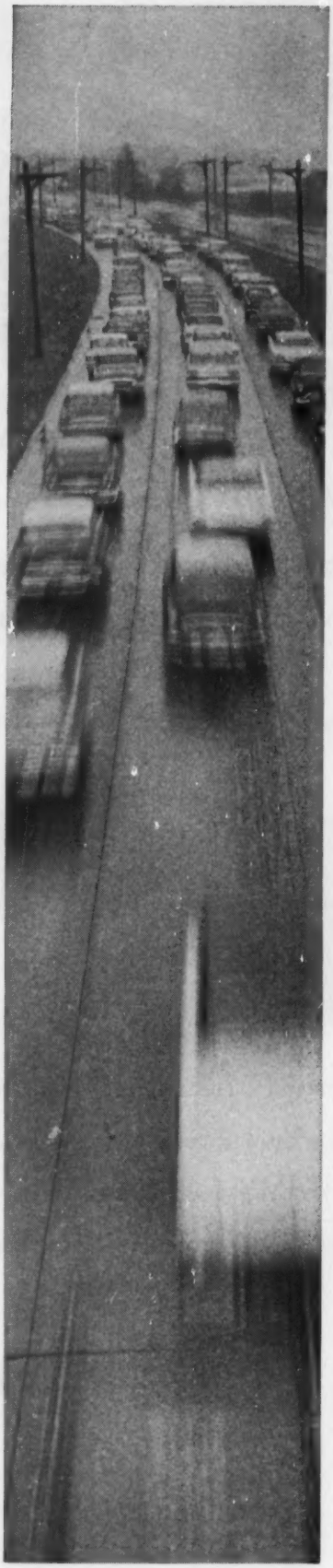
... because only Raybestos-Manhattan makes all types of friction materials! For example:

- **Sintered metal plates**
- **Semi-metallic plates**
- **Cellulose plates**
- **Woven band lining**
- **Molded band lining**
- **Semi-metallic band lining**
- **Cellulose band lining**
- **Plastic friction dampeners**

What does this mean to you? It is your assurance of an unbiased recommendation of the material best for your application.

In addition, you can count on R/M for uniformly high quality; reliability of supply; prompt and extensive engineering, research and development assistance; competitive prices.

An R/M sales engineer can be at your desk within 24 hours if you will call or write. Meanwhile, why not send for our free bulletin of helpful engineering information on friction materials.



RAYBESTOS-MANHATTAN, INC.
EQUIPMENT SALES DIVISION: Bridgeport, Conn.
Chicago 31•Cleveland 16•Detroit 2•Los Angeles 58

of propagation of fracture was very high and the energy to propagate the fractures was not measurable.

Ductility decreased with decrease of temperature, but at any particular temperature the severity of the notch had no appreciable influence on the ductility. The presence of molybdenum improved the ductility of the steel. The appearance of the tear-test fractures of 18:8 plate at temperatures below zero was similar.

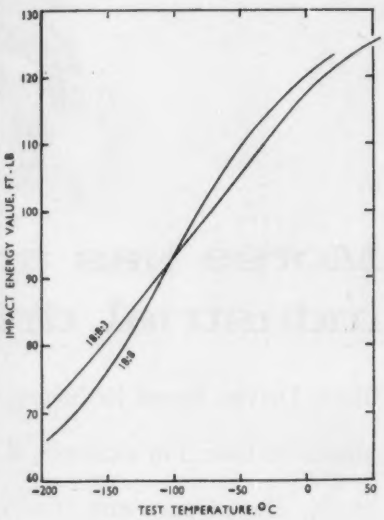


Fig. 6—Effect of temperature on Charpy V-notch impact strength of austenitic stainless steels.

At ambient temperature, the fractures of the 18:8:3 plate were of the double-cup shear type, while at sub-zero temperatures, the fractures were flat and contained continuous fissures.

Although the maximum stresses were the same value at room temperature, at all sub-zero temperatures the molybdenum-bearing steel was 10 to 15 tons per sq in. lower in strength. Below −100 C, the tensile strength of both alloys increased in value.

Nickel Steels: Of the more common alloying elements, nickel has been shown to be outstanding for lowering the ductile-to-brittle transition temperature range of ferritic steels. Three ranges of nickel steels with low carbon content have been tested. Their qualities are covered by the ASTM specification A300. The data obtained for the 9 per cent

Circle 497 on Page 19

The Mastergauge SERIES

and companion "Master-test" group for extreme services requiring the ultimate in accuracy and stamina.

Right Quality SERIES

also for tough services, but less severe than the conditions served by the "Mastergauge"

Gauge Standard SERIES

for the general run of gauge services. Marsh quality and accuracy at a moderate price.

for every need

Within these three comprehensive Marsh groups you have the world's widest (yes, and wisest) selection of pressure gauges. These groups of gauges are not *grades* ...they are *kinds*...the MARSH kind... which means that each gauge, within the scope of its rated use, is the BEST of its kind!

Pick the right Marsh Gauge and you have the best answer to your gauge problem.

Ask for latest data

MARSH INSTRUMENT COMPANY

Division of Colorado Oil and Gas Corporation • Dept. B, Skokie, Ill., Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta • Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas • Eastern Seaboard Warehouse: Marsh Instrument Company, 1209 Anderson Ave., Fort Lee, N.J.

MARSH

GAUGES • THERMOMETERS
VALVES

Circle 498 on Page 19

nickel steel are representative of the properties of the steel in an ideally heat-treated condition. Metallographic examination showed the tempering temperature to be somewhat critical.

The results of tear tests, 1c, on 2¼ per cent nickel steel revealed a slight increase of maximum load with decrease of temperature down to −75 C, but with almost complete lack of ductility at −50 C.

Results of Charpy V-notched impact tests may be summarized:

1. 2¼ per cent nickel steel: A decrease from 111 ft-lb at 0 C to 36 ft-lb at −75 C, with 50 per cent crystallinity of the fracture at about −40 C.
2. 3½ per cent nickel steel: A decrease from 190 ft-lb at 0 C to 10 ft-lb at −120 C, with 50 per cent crystallinity of the fracture at −75 C.
3. 9 per cent nickel steel: A gradual decrease from 132 ft-lb at 0 C to 60 ft-lb at −196 C, with only 40 per cent crystallinity at the latter temperature.

Paper No. 2043, *"The Properties of Some Metals and Alloys at Low Temperatures," Journal of the Institute of Metals, Vol.* 89, 1960-61, *pp.* 145 *to* 161.

techniques

Engine Vibration Analysis

E. J. Emkjer, Convair

The use of fixed, narrow bandwidth techniques to isolate vibration sources in jet engines.

The method of eliminating the high frequency oscillator and details of the circuitry employed are shown in block diagrams and simple schematics.

Synchronizing the vibration analyzer to provide accurate tracking is accomplished by an electro-optical method which generates sine waves with less than 1 per cent total distortion.

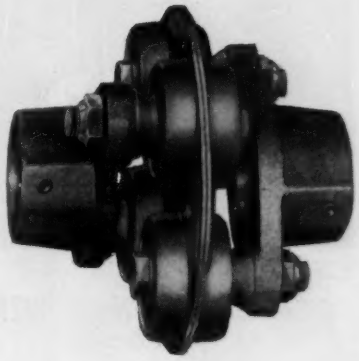
IRE Paper No. 4, *"Modern Engine Vibration Analysis," presented in Session* 3D, *IRE Winter Convention on Military Electronics, Los Angeles, Feb.*, 1961.

Semi-Invariant Method of Statistical Design

O. L. Draper, General Electric Co.

A method of design, using semi-invariants, that will allow the designer

A Morse answer



Morflex couplings

...when the problem involves vibration and misalignment

Isolate vibration

Cushion shock

Absorb misalignment

Torsionally flexible

Impervious to water, dirt, oil

Arrest electrolysis

Distributor-stocked

Got a coupling problem? Call your Morse distributor. He's listed in the Yellow Pages.

MORSE

A BORG WARNER INDUSTRY

BW

Morse Chain Co., Dept. 6-31, Ithaca, N.Y. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.

Circle 499 on Page 19

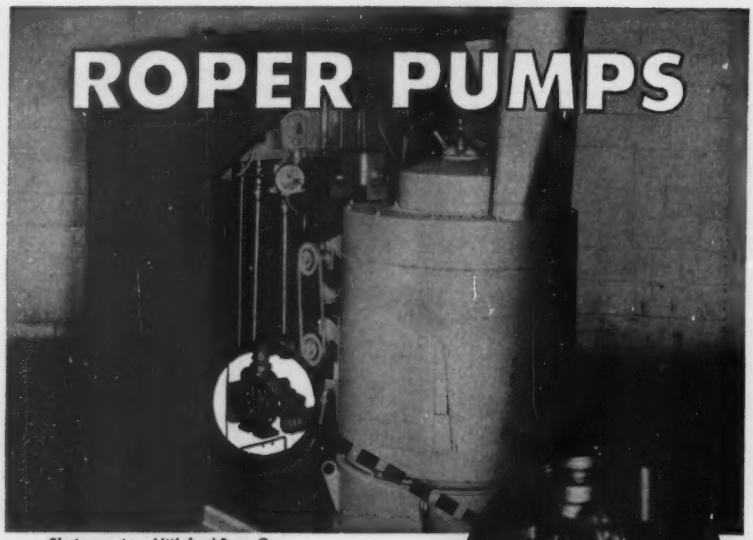


Photo courtesy Littleford Bros. Co.

Series 3600 • Model HBZRV-2A
SPEC. 2422

circulate oil uniformly through heating area of hot oil heater

Model OH 14 hot oil heater, manufactured by Littleford Bros. Co., produces 450°F hot oil for use in operations such as prestressed and ready-mixed concrete, and asphalt plant work. This positive displacement Roper Series 3600 pump moves 50 gpm of heat transfer oil smoothly and positively, circulating the oil thoroughly in heating area to eliminate cold or hot spots where deterioration of oil could occur. The relief valve of the pump protects against excessive oil pressure. The dependable, pulsation-free flow provided by the Roper pump has proved to provide the kind of performance manufacturers of original equipment want. Roper's service to the OEM field includes a custom design department equipped to design and build special pump equipment to match the changing needs of manufacturers.

Engineered for Years-Of-Service Operation

• **TWO MOVING PARTS**—equal sized, helical gears run in axial hydraulic balance for efficient operation. • **STEEL SHAFTS**—induction-hardened at all bearing and packing surfaces . . . pump can be supplied with upper or lower drive shaft. • **BEARINGS**—full support for pumping gears comes from four high-lead bronze or chrome-iron bearings. • **RELIEF VALVE**—built into face plate, prevents pressure build-up, permits stoppage of flow without halting pump . . . adjustable over 20-100 psi range.

For information about your specific pump needs contact your nearest Roper dealer
Send for "How to Solve Pumping Problems" booklet

ROPER HYDRAULICS, INC.

Dependable pumps since 1857
COMMERCE, GEORGIA

to determine the probability of a circuit being useful at the end of a given time. From the definition of semi-invariants, their value in solving summation problems is shown. Then, the relationship between semi-invariants and the moments about the mean, commonly called the central moments, is developed.

Semi-invariants are used to obtain the frequency function of a design equation for a much-used digital circuit, the inverter. Advantages of this method are ease of application and low cost.

IRE Paper No. 2, "Semi-Invariant Method of Statistical Design," presented in Session 1D, IRE Winter Convention on Military Electronics, Los Angeles, Feb., 1961.

Magnetic Digital Data Storage Devices

E. U. Cohler, M. I. Crystal, H. A. Ullman, Data Systems Operations, Sylvania Electronics Systems Div., General Telephone & Electronics Inc.

Performance characteristics of digital data storage devices and methods for adopting them to military environments. For mass memories or data-retrieval files, solutions such as magnetic tape, discs, and drums have storage capabilities up to billions of bits and low cost per stored bits. The favorable characteristics carry with them liabilities of slow random access and sensitivity to a variety of environmental conditions. Methods to simplify and minimize maintenance and improve reliability in extreme environments have ranged from simple repackaging to complete redesign. New design philosophies for military requirements are proposed.

IRE Paper No. 1, "Magnetic Digital Data Storage Devices and Their Application to Military Systems," presented in Session 1C, IRE Winter Convention on Military Electronics, Los Angeles, Feb., 1961.

Worth Concept In System Planning

R. Shuster and D. Blattner, Radio Corp. of America

Evaluation and selection of complex systems facilitated by isolating the factors used in judging relative "worth." Worth is defined in terms of a mathematical model which re-

Circle 500 on Page 19

Straits Tin Report

Tin-lined copper tube recently developed combines tin's corrosion resistance and malleability with the strength and ductility of copper. Pure molten tin is gas-propelled through the tubing to form a continuous, fusion-bonded tin lining that will not chip, crack or peel, and can be

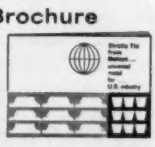
Photo courtesy Phelps Dodge

bent, flared, flattened or soldered. Tin provides immunity to corrosive sulfur conditions found in some natural gas and petroleum products; affords excellent resistance to flaking action that can plug lines and orifices and create hazards with gas appliances. The tin lining also prevents contamination of fluids in process lines of food, beverages, pharmaceutical and water distilling equipment and for sampling lines to laboratory or control instruments, according to its producers, Phelps Dodge Copper Products Corp.

Acid pickling of steel before hot tinning produces maximum bond strength of bearing metal to steel. Shot blasting preparation lowers bond strength, possibly because of distortion, folding and flowing during precleaning.

FREE Brochure

16 interesting pages of information about the latest uses of tin in U.S. industry. Write today for your copy.



The Malayan Tin Bureau
Dept. S-29C, 2000 K St., N.W., Washington 6, D.C.

Circle 501 on Page 19

lates all the measurable parameters that apply to the system under analysis. Methods are discussed for numerical determination of these parameters in terms of normalized performance coefficients. As a practical illustrative problem, techniques that have been developed are demonstrated by a parametric study leading to selection of an optimum communication system.

IRE Paper No. 1, "The Worth Concept An Aid to System Planning," presented in Session 3C, IRE Winter Convention on Military Electronics, Los Angeles, Feb., 1961.

Land Navigation and Position Fixing System

C. L. Wetzel, Bendix Corp.

Design of an advanced position fixing and navigation system. Features of the system are: High mobility, low weight, accuracy, reliability and low frequency operation.

The system comprises three subsystems: Transmitting, receiving (unlimited number of users), and map correlating.

System covers approximately 150,000 square miles and achieves accuracies up to a repeatability of 25 feet.

The entire system is easily transportable by air or ground vehicles.

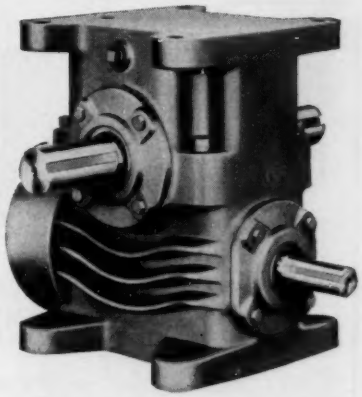
IRE Paper No. 3, "Position Fixing and Navigation of Army Field Units," presented in Session 1E, IRE Winter Convention on Military Electronics, Los Angeles, Feb., 1961.

Reliability Application And Analysis Guide

D. R. Earles, The Martin Co.

A guide for estimating reliability when a design comparison or a design capability estimate is desired. Procedures and data are included related to reliability, mean-time-to/between-failures, design growth, and preferred component applications. A table of typical shelf life has also been included. Reliability specifications, standards, and bulletins are delineated. Reliability diagrams are discussed and techniques for the design and development of a reliable piece of electrical equipment are outlined. Application information is available

A Morse answer



Eberhardt-Denver

poweRgear®

...when the problem involves heavy duty and reliability

- High horsepower capacity
- Oversize shafts
- Extra-large bearings
- Heavy-duty gearing
- Universal mounting
- All types available
- Fractional to 53 hp. loads
- Ratios 5:1 to 3600:1
- Center distances 2" to 7"
- Distributor-stocked

Got a speed-reducer problem? Call your Morse distributor in the Yellow Pages.

MORSE

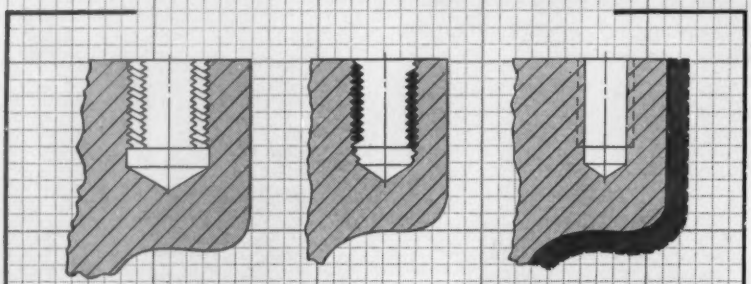
A BORG-WARNER INDUSTRY

BW

Morse Chain Co., Dept. 6-31, Ithaca, N.Y. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.

Circle 502 on Page 19

How You Can Save Boss Space and Weight in Thread Design ...with HELI-COIL® Inserts

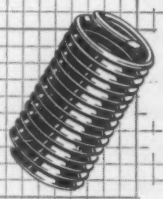

Solid bushing requires oversize boss
Heli-Coil Insert permits standard boss proportion
Space and weight saved by Heli-Coil Insert

As seen in the illustrations above, *Heli-Coil* Inserts save 56% in space, 63.5% in weight.

Heli-Coil stainless steel wire inserts have a smaller outside diameter than any solid bushing. Therefore, with ***Heli-Coil*** Inserts you can design boss radii to a minimum, yet stay with standard boss configurations. This means *savings in space and weight*, and material-savings as well.

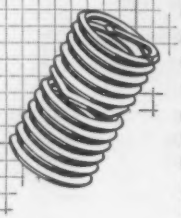
This feature is vitally important for miniaturization in aerospace design, in electrical and electronics equipment design, and for general industrial applications.

NO OTHER TYPE OF INSERT OFFERS SUCH SAVINGS!



Heli-Coil Standard Insert
for stronger, smoother, lifetime threads

Permanently protects threads against wear, stripping, corrosion, galling, seizing, vibration, and shock. Made of 18-8 stainless steel wire, this precision-formed ***Heli-Coil*** Insert has a tensile strength of approximately 200,000 psi. Conforms to military standards and all commercial and industrial thread forms.



Heli-Coil Screw-Lock Insert
eliminates lock wiring and lock nuts

This one-piece wire Screw-Lock Insert provides all the thread protection of the Standard Insert, PLUS an exclusive resilient *internal* locking feature that eliminates clumsy protruding lock nuts, lock wiring and other supplementary locking devices. *It saves cost, space and weight* – permits simple streamlined design in standard bosses. Meets military and N.A.S. specifications for locking torque and vibration.

The ***Heli-Coil*** *line of products includes: inserts and related taps, hand tools, power inserting tools, automated tooling, and gages. Tables of boss radius and weight comparison are available. Write for complete details and design data.* 2565A

HELI-COIL CORPORATION
503 Shelter Rock Lane, Danbury, Connecticut
In Canada: ARMSTRONG BEVERLEY ENGINEERING LTD.
6975 Jeanne Mance St., Montreal 15, Que.

for most electronic component parts. The systems outlined for a design analysis are not intended to supplant engineering judgment for experience, but are given to aid the decision-making process.

IRE Paper No. 1, "Reliability Application and Analysis Guide," presented in Session 1D, IRE Winter Convention on Military Electronics, Los Angeles, Feb., 1961.

materials

Contamination of Titanium By Water Vapor

P. C. Hughes, and I. R. Lamborn, Australian Defense Scientific Service, Dept. of Supply, Victoria, Australia.

General trends in hydrogen contamination of titanium at elevated temperatures, and the influence of concurrent oxidation under particular conditions. The variables humidity, temperature, and time were investigated. Hydrogen contamination in moist, but otherwise inert, atmospheres was negligible below 590 C. Results suggest that in moist oxidizing atmospheres, this threshold temperature will be raised. The competing effects of hydrogen and oxygen diffusion on microstructure are illustrated.

Paper No. 2045, "Contamination of Titanium by Water Vapour," Journal of the Institute of Metals, Vol. 89, 1960-61, 4 pp.

Plastisol Extrusion Coating

C. H. Brower, Union Carbide Plastics Co., and R. A. Nunn, Waldron-Hartig Div., Midland-Ross Corp.

Comparison of methods for coating with vinyl dispersions. Normally vinyl dispersions are applied to cloth and other substrates by roller or knife coating. A new method for applying these materials has been recently developed, involving plastisol extrusion lamination.

Extrusion coating of vinyl plastisols offers some distinct advantages over knife and roller coating methods. These stem from the fact that extrusion-coated plastisols are applied in a fused condition. Particular advantages include:

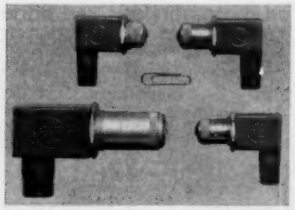
1. Capital investment in equipment is less than conventional methods.
2. Savings in floor space and power

Automation Components

MINIATURE PHOTOELECTRIC SCANNER

Proximity sensor Type SA-1R contains light-source, photocell, and an infrared filter, all in a small anodized-aluminum housing with standard four-prong connector. The solid-state photocell is sensitive, sturdy, and sealed for protection against moisture, dust, or corrosive atmospheres. This scanner operates on reflected light, is responsive to metallic and non-metallic objects. Two models available. Write for Bulletin 260-A.

Type	Max. Sensing	Lamp rating
SA-1R	up to 2 inches	5 v. a-c 60,000 hrs.
SA-1RM	up to 6 inches	2 v. a-c 5,000 hrs.



Short-range scanner SA-1 and medium-range scanner SA-1M consist of two units, the light source and the photocell unit. These small-size scanners have adjustable focus of light-beam for high-precision scanning of rapidly moving parts, with beam-interruption by $1/32$" objects. Eyeshade and infrared filter available to increase range and effectiveness. Write for Bulletin 659.

Type	Max. Sensing	Lamp rating
SA-1	up to 4 feet*)	6 v. a-c 5,000 hrs.
SA-1M	up to 12 feet*)	5 v. a-c 5,000 hrs.

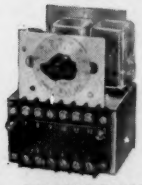
*) can be increased 50% by using eyeshade and infrared filter.

PHOTOELECTRIC RELAYS

Type PE3 — General-purpose relay
Type PE4 — High-speed-impulse relay
Type PE5 — Time-delay relay
Type PE7 — Photo-electric timer

For use with photoelectric scanners; provide suitable light-source voltages; DPDT load contacts handle 8 amperes (non-inductive) at 115 volts a-c.

CK ELECTRONIC TIMERS



Model 120 General-Purpose timer features cold-cathode tube and identical plastic-enclosed plug-in relays, has seven basic modes of operation, including repeat-cycle timing. (Size 4⅞" x 3¾" x 3½".) For information on timers write for Bulletin 120.

SYNCHRONOUS CONTACTORS

Rotating camshaft actuates distributor-type switches. Single and double-circuit models available. Write for Bulletin "Rototimer".

Whatever your problem in Automation Components, FARMER can help you.

FARMER ELECTRIC
Products Company, Incorporated
2300 WASHINGTON ST. NEWTON LOWER FALLS, MASS.

consumption are realized.
3. No subsequent heating steps are required.
4. "Strike through" problems are nonexistent.
5. Rheological problems are not as critical—giving greater formulation latitude.

On the other hand, extrusion coating does not have the gauge control of roller coating, and adhesion must be promoted with primers in some cases.

SPE Paper No. 27-1, "Comparison of Plastisol Extrusion Coating with Conventional Coating Methods," presented at the Seventeenth Annual Technical Conference of the Society of Plastics Engineers, Washington, D. C., Jan., 1961, 4 pp.

hydraulic

Systems for Super-Clean Hydraulic Fluids

D. R. Walker, Propulsion and Mechanical Engineering Testing Div., Douglas Aircraft Co.

Systems and design considerations, as in missiles, for keeping hydraulic fluids super-clean. The term super-clean means cleaner than fluid defined by military specification MIL-H-5606B. In one suitable fluid, requirements are that 100 milliliters of fluid must contain fewer than ten particles larger than 40 microns, and produce no background color when filtered through an 8-micron membrane 47-mm in diameter.

NCIH Paper, "Control of Hydraulic Fluid Contamination," presented at the 16th National Conferences on Industrial Hydraulics, Chicago, Oct., 1960, 9 pp.

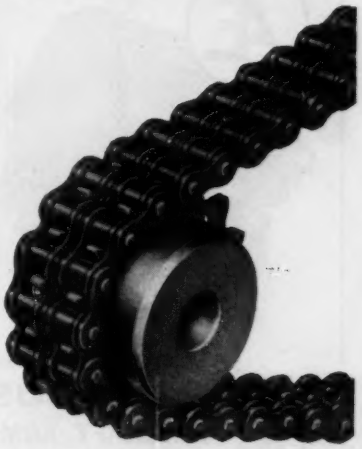
electrical

Electroluminescent Display System

J. L. Hallett, Sylvania Electronic Systems

An experimental display using segmented electroluminescent devices for readout of information. The system operates from binary-coded number and information which is supplied from perforated tape or from a manually operated keyboard. Data are entered and updated automatically. The logic and display portions of the system use solid state

A Morse answer



roller chain

...when the problem involves service life and performance

Superior fatigue resistance
Increased horsepower ratings
Statistical hardness control
Electronically controlled pitch
All parts automatically inspected
Drive-design service
Distributor-stocked

Got a chain problem? Call your Morse distributor. He's listed in the Yellow Pages.

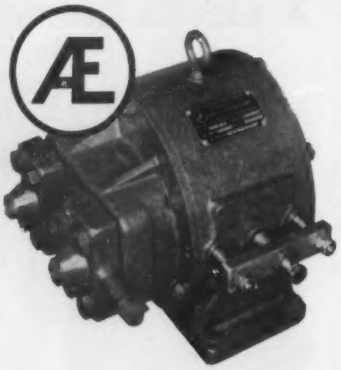
MORSE
A BORG-WARNER INDUSTRY
BW

Morse Chain Co., Dept. 6-31, Ithaca, N.Y. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.

Circle 504 on Page 19

Circle 505 on Page 19

IMPORTANT NEWS
FOR HYDRAULIC PUMP USERS



AMERICAN ENGINEERING'S HELE-SHAW and **HYDRAMITE** pumps are now being precision engineered and fabricated at the Aircraft Armaments, Inc. plant at Cockeysville, Md.

Be assured that the same craftsmanship and high standards of quality which make **HELE-SHAW** and **HYDRAMITE** pumps leaders in their field will be maintained in the **IMMEDIATE CONTINUED PRODUCTION** of these pumps by Aircraft Armaments, Inc.

Please address inquiries to:

AE INDUSTRIAL DIVISION
AIRCRAFT ARMAMENTS, INC.
Post Office Box 6853, Baltimore 4, Maryland
CLEVELAND DISTRICT: A. E. Company, 1157 Leader Bldg., Cleveland 14, Ohio
NEW YORK DISTRICT: AE Industrial Division, 1 Exchange Place, Jersey City 2, N. J.

Circle 506 on Page 19

Wolverine TOGGLE CLAMPS
Cost Less per Thousand Clamping Operations

Note These Important Features:

- HARDENED PINS and BUSHINGS
- HEAVY BODY SECTIONS
- BLACK OXIDE FINISH
- PINS RIVETED FLUSH
- DROP-FORGED ARM

Many Types to Satisfy Your Work Holding Needs

8 STANDARD ACTION UNITS
10 QUICK ACTION UNITS
12 PUSH ACTION UNITS & others

WRITE for CATALOG - PRICES - Template Sheets Available

WOLVERINE TOOL CO.
1242 E. WOODBRIDGE
DETROIT 7, MICHIGAN

circuitry. Conversion from binary to display code is performed by photoconductive/electroluminescent matrices.

IRE Paper No. 3, "An Experimental Electroluminescent Display System," presented in Session 4C, IRE Winter Convention on Military Electronics, Los Angeles, Feb., 1961.

mechanical

Braking of Road Vehicles

K. N. Chandler, Road Research Laboratory, Dept. of Scientific and Industrial Research, Great Britain.

Basic properties of a pneumatic tire, and mathematical consideration of a pneumatic-tired wheel, bearing a load during braking and during the release of brakes. By numerical estimates, it is shown that, from 15 mph, a wheel could lock within 18 milliseconds.

Equations are derived for operation of a commercial device designed originally to release the brakes of an airplane before the wheels lock on landing and then later to reimpose the brakes. The equations apply to operation in any road vehicle.

Highly simplified calculations suggest that, in its present form, a much longer braking distance will result from using the device than would be obtained with locked-wheel braking.

IME Paper No. AD 8/60, "Theoretical Studies in Braking," accepted for publication after March 31, 1961.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to:

Institute of Metals, 17 Belgrave Square London S.W. 1, England.

IME—The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London S.W. 1, England.

For papers presented at the 1961 Winter Convention on Military Electronics, contact authors.

NCIH—National Conference on Industrial Hydraulics, sponsored by Illinois Institute of Technology, 3300 South Federal St., Chicago 16, Ill., Vol XIV, Conference Proceedings, 6 dollars each.

SPE—Society of Plastics Engineers, 65 Prospect St., Stamford, Conn.

Circle 507 on Page 19

new–lube-free

Sterling's variable speed drive never requires lubrication

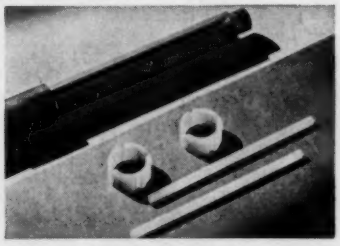
STERLING
Sealed and shield bearings require no lubrication.
Keys are fabricated from tough elastic material to eliminate key and keyway wear.
Wear-resistant non-metallic bushings require no lubrication.
Shaft surfaces are corrosion-proof and require no lubrication.

All lubrication maintenance problems are eliminated by Sterling's new variable speed drive. Fret corrosion is completely eliminated. Sticky pulleys, resulting from improper lubrication, are no longer a problem. Belt life is lengthened; pulley wear is eliminated.

Special load-bearing surfaces never require any attention or lubrication. Keys and bushings will not wear out. Shaft surfaces are also tough and wear resistant.

Sterling's new "Lube-Free" variable speed drive can be installed in any location, no matter how inaccessible, since lubrication maintenance is no longer needed.

Complete application and product information is available by writing Dept. S-1, Sterling Electric Motors, Inc., 5401 Telegraph Road, Los Angeles 22, California—or by contacting the Sterling field engineer in your area.



Tough shaft surfaces provide unusual chemical resistance and anti-frictional properties. Specially fabricated keys and bushings hold up indefinitely.

Hathaway INSTRUMENTS INC.

Sterling Electric Motors, Inc.

5401 TELEGRAPH ROAD, LOS ANGELES 22, CALIFORNIA,
A Subsidiary of HATHAWAY INSTRUMENTS, INC.

Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Self-Cleaning Strainers

Catalog 6008 details over 600 standard strainers and shows wide selection of available body materials, end connections, pressure ratings, and sizes. Complete pressure-drop and pressure-temperature limit data are provided. Free-hole areas for the more than 300 standard available screens are also included. Body materials, end connections, and pressure-temperature ratings are compiled into tables keyed to a single catalog number for identifying and specifying. 12 pages. Strainer Section, Leslie Co., 507 Grant Ave., Lyndhurst, N. J.

Circle 701 on Page 19

Pressure Transducers

Data folder contains a glossary of pressure-transducer definitions and describes SP-2 series of transducers. Covered in the glossary are transducer types, sensing-element types, pressure range, strain-gage characteristics, performance parameters, compensation, and shunt calibration. Separate sheets describe the transducers, and give advantages and all specifications. 12 pages. Standard Controls, 1130 Poplar Place, Seattle 44, Wash.

Circle 702 on Page 19

Rotary-Armature Relays

Catalog 860 provides information on rotary balanced general-purpose relays, including photographs, line drawings, and all specifications. Appendix includes general data on contact load and life, contact resistance, relay materials, shock and vibration, dry-circuit relays, coil circuits, contact arc suppression, and other data. 24 pages. Hi-G Inc., Bradley Field, Windsor Locks, Conn.

Circle 703 on Page 19

Electronic Equipment

New abridged catalog provides data on 24 conventional oscilloscopes, six portable oscilloscopes, and 12 rack-mounted versions. Other associated electronic equipment is also pictured and briefly described. Photograph and specification data are included for each unit listed in the catalog. 16 pages. Tektronix Inc., P. O. Box 500, Beaverton, Oreg.

Circle 704 on Page 19

Wirewound Resistors

Line of encapsulated precision wirewound resistors providing high performance in small size is described in two-color folder. Complete specifications and technical data are given, including derating curves and curve showing resistance change versus temperature change. Military types are designated, showing the company's equivalents. Dimensional drawings and tables are included. 4 pages. Hanjohn Co. Inc., 9834 E. Alpaca St., South El Monte, Calif.

Circle 705 on Page 19

Control, Indicating Components

"Precision Products for Precision Control" defines five new divisions of control and indicating components and packages. Folder illustrates several representative devices, components, and packages in each of the five product classifications, providing general technical data and descriptions for each product shown. 6 pages. Bowmar Instrument Corp., 8000 Bluffton Rd., Ft. Wayne, Ind.

Circle 706 on Page 19

Circuit-Breaker Load Centers

Complete descriptions, wiring diagrams, dimensions, and selector tables for line of circuit-breaker load centers are contained in Catalog C-200. Simplified guide to panel selectors is featured, and advantages of the various units described are listed. Full-page selector tables are included for single-phase, main-lug, split-bus, and main-breaker panels, and for three-phase main-lug panels. Catalog is punched for insertion in loose-leaf and spring binders. 20 pages. Bryant Electric Co., Box D, Barnum Station, Bridgeport 2, Conn.

Circle 707 on Page 19

Flexible Couplings

Catalog 61, Section A, provides information on a full line of couplings in bore sizes from solid to 9½ in. All couplings are pictured and described, and dimensional drawings and tables provide engineering data. Tables for varying or pulsating load conversion and horsepower to torque conversion are included. List of standard keyways and engineering formulas and equivalent data completes the bulletin. 22 pages. Lovejoy Flexible Coupling Co., Dept. A, 4945-4949 W. Lake St., Chicago 44, Ill.

Circle 708 on Page 19

Welding Alloy Chart

Welding, brazing, and soldering alloys and fluxes can be selected rapidly according to the base metal to be joined by using new ready-reference, 19½ x 25½-in. wall chart. It includes complete line of alloys and fluxes for joining all commercial metals, indexed under common base metals. Each joining alloy is described with recommended preheats, amperage or working temperature, tensile or shear strengths, identification, and packaging comments. Table shows correct joining alloy for welding or brazing all major weldable aluminum alloys. All-State Welding Alloys Co. Inc., White Plains, N. Y.

Circle 709 on Page 19

Steel Selection

"Three Keys To Satisfaction" is a revised guide to combining sound design principles, proper selection of steels, and good treatment to achieve economy and good material performance. Separate sections on design, steels, and treatment, illustrated with tables and charts, contain much basic information. Steel section deals mainly with heat-treated alloy steels used at tensile strengths below 200,000 psi. 77 pages. Climax Molybdenum Co., Div., American Metal Climax Inc., 1270 Avenue of the Americas, New York 20, N. Y.

Circle 710 on Page 19

Pipe and Tubing Measurement

"How to Measure and Relate Pipe, Tubing and Hose Sizes," Bulletin 631, supplies standard methods of measurements. Both similarities and differences involved in measuring various fittings and fluid-carrying lines are discussed. Pamphlet also discusses standard practices of measuring adapters and complete assemblies; dash-numbering systems are explained in chart form. 16 pages. Aeroquip Corp., Jackson, Mich.

Circle 711 on Page 19

Silicone Compounds

"Silicones for the Space Age," Bulletin CDS-276, is illustrated with photographs and charts to permit quick selection of a silicone compound. Several types of silicone compounds are discussed, including dielectric and lubricating greases and high-temperature paint additives. 16 pages. Silicone Products Dept., General Electric Co., Waterford, N. Y.

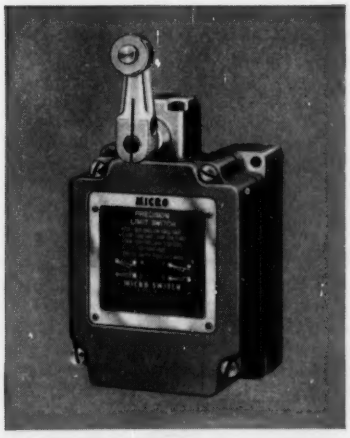
Circle 712 on Page 19

Force Transducer

Booklet describes this mechanical-to-electrical conversion element for the continuous measurement and control of tension, pressure, weight, and thrust. Features and design details are pointed out, using photographs and line drawings. Dimensional drawings are included for two models. Hydro-Pneu-Tronics Inc., 3666 E. 116th St., Cleveland 5, Ohio.

Circle 713 on Page 19

Neon Check Light Signals Operating Position!



New "301LS" is another in MICRO's line of "Plug-in Limit" Switches. This model contains 2 basic switches, each with a normally open and normally closed circuit.

The new "LS" Limit Switch has a translucent plastic insert and enclosed neon light that tell at a glance whether the switch is functioning. Perfect answer for checking switches that must be located in inaccessible or poorly lighted areas, or where it is important to be able to check a large number of limit switches on a production line in minimum time. The new switch is an addition to MICRO's line of compact, high capacity "LS" Limit Switches. Write for Data Sheet 185.

New "301LS" has two basic switches which are operated when the actuating lever is moved clockwise or counterclockwise. Internal adjustments are easily made to provide sequence operation of the two enclosed switches. Sequence control is useful on tool slides to 1) switch from rapid traverse to feed rate and then 2) with the second switch, return the tool to the original position. Sequence control is also used as a positive limit stop where machine damage could occur by a fault in the first switching circuit. See the Yellow Pages for your nearby MICRO SWITCH Branch Office or write for Data Sheet 187.

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls, Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH Precision Switches

Circle 509 on Page 19

WAPAK HARDENED WAYS LAST LIFETIME OF YOUR MACHINES

Engineered from solid tool steel, WAPAK Hardened Ways are uniformly hard through and through . . . No galling, scoring or other failure throughout lifetime of your machines . . . even under rugged service. Carburized or laid steel ways also available in some sizes.

ACCURATE FINISH

Utmost care is given to accuracy of finish on all WAPAK Hardened Ways. Micro grinding is followed by individual inspection of each piece with Profilometer.

ENGINEERED TO SPECIFICATIONS

WAPAK Ways are manufactured to your blue print specifications and normal deliveries maintained. Your machines are more reliable with WAPAK Hardened Ways.

THE WAPAKONETA MACHINE CO.

Knives Engineered for the Job Since 1891

WAPAKONETA 9, OHIO

Also manufacturers of SLITTER KNIVES • SHEAR BLADES • ROTARY SHEAR KNIVES • SCRAP CHOPPERS • HARDENED SPACERS • GIBS • ROCKER PLATES • WEARING PLATES • BALL RACES • WEAR STRIPS • MACHINE LINERS • MACHINE KNIVES for all industries

Subminiature Connectors

Catalog D2-1 describes fast-assembly, ConheX subminiature R.F. connectors for RG and other coaxial cables. In addition to plugs, jacks, bulkhead receptacles, feed-throughs, right-angle units, cable terminations, tee adaptors, and printed-wiring-board units, catalog describes broad lines of adaptors, BNC and TNC plugs. Photographs, line drawings, dimensional drawings, and tables provide data. 12 pages. Sealectro Corp., 139 Hoyt St., Mamaroneck, N. Y.

Circle 714 on Page 19

Industrial Coated Fabrics

Physical properties, performance characteristics, and applications of more than 200 different styles of Reevecote industrial coated fabrics are listed in new catalog. Three reference tables list characteristics of eight different textile fibers, effects of chemicals on 12 different elastomers, and comparison of elastomer properties. Applications listing is also included. 12 pages. Vulcan Div., Reeves Brothers Inc., 1071 Avenue of the Americas, New York 18, N. Y.

Circle 715 on Page 19

Electric Motors

Complete specification data are given for Series M shaded-pole induction motors and for models in helical, spur, and worm gear motors. Description includes photographs, speed ranges, torques, sizes, gear descriptions, and optional features. Catalog simplifies selection of the exact motor to meet specific needs. Drawings show shaft, mounting, and outline dimension. 4 pages. Brevel Products Corp., 601 W. 26th St., New York 1, N. Y.

Circle 716 on Page 19

Servo Systems

Colorful new booklet provides data on various types of servo systems developed to meet specifications. Many applications of the units are shown, along with pictures and complete specifications. About 20 pages. Systems Div., Clifton Precision Products Co. Inc., 5050 State Rd., Drexel Hill, Pa.

Circle 717 on Page 19

Pushbutton Station

Flexitite all-rubber pushbutton station for oiltight and heavy-duty service is described in Bulletin B82. Included are illustrations, construction and performance details, and explanation of features. 4 pages. Electrical Products Div., Joy Mfg. Co., 1201 Macklind Ave., St. Louis 10, Mo.

Circle 718 on Page 19

Electric Motor Components

New catalog shows molded brush retaining caps, carbon brush holders, commutators, and slip rings. Complete data include pictures, dimensional drawings, and size information. 12 pages. Midwest Molding & Mfg. Co., Gurnee, Ill.

Circle 719 on Page 19

Circle 510 on Page 19

Weight Sensing

New reference manual shows how a principle of weight sensing or force measurement can be applied for automatic control. Principle is based on the use of 1:1 ratio predetermined weight scale and automatic electrical readout. Diagrams show representative applications, and pictures of typical applications are also included. 8 pages. Exact Weight Scale Co., 917 W. 5th Ave., Columbus 15, Ohio.

Circle 720 on Page 19

Ball Valves

Reference Book 39, Section 5, describes new ball valves that provide quick, effective fluid control. Catalog pictures the various types and gives all dimensions. Cutaway drawing and line drawing are used to demonstrate the key features of the valves. 8 pages. Homestead Valve Mfg. Co., Coraopolis, Pa.

Circle 721 on Page 19

Rubber Products

General Catalog M5 describes complete line of rubber products for industry. Included are sections on Poly-V drive, V-belts, transmission belt, conveyor belt, and all types of hose, flexible rubber pipe, and expansion joints. Catalog gives basic specifications and information for ordering. Details on the design and operating advantages of new constructed products are included. 24 pages. Manhattan Rubber Div., Raybestos-Manhattan Inc., Passaic, N. J.

Circle 722 on Page 19

Welding Stainless Steel

Information concerning techniques for welding stainless steel is contained in Bulletin 7300.2, "Arc Welding Stainless Steel." Bulletin gives physical properties, structure, and welding characteristics of the different types of stainless. Chart listing deposit properties, and electrode recommendation tables for the various types of stainless are included. 12 pages. Lincoln Electric Co., Cleveland 17, Ohio.

Circle 723 on Page 19

Switch Selection

New catalog provides information on the selection and ordering of switches. Applications, materials, and characteristics of the switches are listed. Described and illustrated are standard types and many special units. Line drawings, pictures, and tables provide all data. 48 pages. Daven Co., Livingston, N. J.

Circle 724 on Page 19

Flowmeter Kits

Four variable-area flowmeter kits, each containing meters of various sizes for a wide range of flow measurements, are described in Bulletin 10A1010. Contents of each kit are listed, along with complete data on performance, operational limits, and capabilities. 4 pages. Fischer & Porter Co., 794 Jacksonville Rd., Warminster, Pa.

Circle 725 on Page 19

as simple as . . .

THE HP5 SERIES CYCL-FLEX FOR TIME CONTROL

Yes, our *New* Cycl-Flex Timer is as easy to adapt and change as a simple electric plug.

Don't let automation troubles get you down! . . . use our New Cycl-Flex for TIME CONTROL functions. Should your automatic controls fail for any reason, you can trace your trouble by plugging-in a spare timer. Movement of the TIME pointer indicates whether trouble is in the input or the output circuits.

Eagle's New Cycl-Flex Timer has been enthusiastically adapted by leading manufacturers of molding presses, dielectric heaters, machine tools and feed controls.

Write for Bulletin 125 or call your local Eagle Representative. He's listed in Sweet's Product Design File, Section 7d, or in Thomas Register.

SPECIFICATIONS • 10 sec. to 60 hr. dial • 2 instantaneous switches • 2 delayed switches • 12 terminals • Resets in 1/3 sec. • Mounts in 3 1/8" dia. hole

MANUFACTURERS OF THE MOST COMPLETE LINE OF INDUSTRIAL TIME-COUNT CONTROLS AVAILABLE

Precision Interval Timers | Multiple Circuit Timers | Heavy-Duty Step Switches | Multiple Cam Timers | Predetermined Counters | Hermetically Sealed Timers

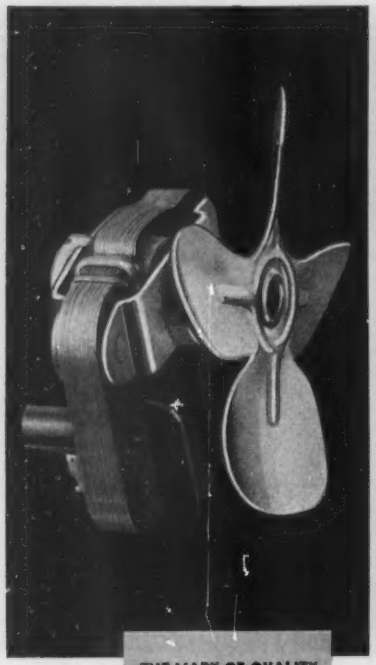
BLISS

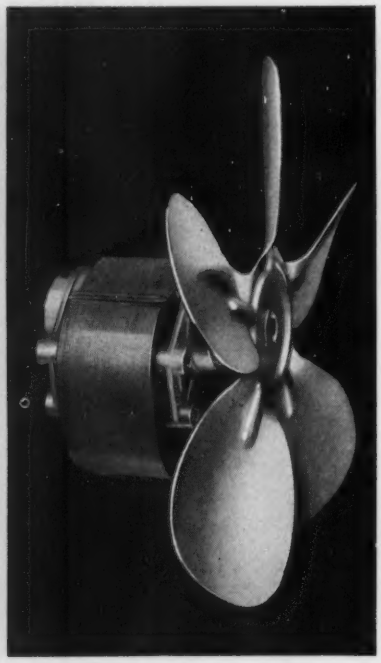
EAGLE SIGNAL COMPANY • Moline, Illinois
INDUSTRIAL DIVISION

A DIVISION OF THE GAMEWELL COMPANY, AN E. W. BLISS COMPANY SUBSIDIARY

Circle 511 on Page 19

Barber-Colman unidirectional shaded pole motors with choice of 3″ through 8″ dia circulating fans . . . ratings from 75 to 1,080 cfm





THE MARK OF QUALITY

BARBER COLMAN

a-c small motors

As manufacturer of unidirectional small motors up to 1/20 hp, Barber-Colman offers various combinations of these motors and fans for applications such as listed at left. These high-quality motors feature low noise level . . . high dielectric strength coils . . . stainless steel shafts . . . long-life lubrication. For complete information on Barber-Colman Motors with fans, write for bulletin F-1.

TYPICAL APPLICATIONS
AIR PURIFIERS
DEODORIZERS
HUMIDIFIERS
REFRIGERATOR BLOWERS
ELECTRIC HEATERS
BOOSTER FANS
VENTILATORS
PROJECTORS
DESK FANS

THE WIDE LINE OF BARBER-COLMAN A-C MOTORS includes unidirectional, synchronous, and reversible types . . . with or without reduction gearing . . . open or enclosed. Stator and rotor sets also available. Write for quick reference file.

SEE SERVO MOTOR DEMONSTRATION . . . IRE SHOW . . . BOOTHS 2242-44

BARBER-COLMAN COMPANY

Dept. O, 1273 Rock Street, Rockford, Illinois

HELPFUL LITERATURE

Kralastic ABS Plastics

Illustrated booklet describes how ABS plastics can be used in engineered applications. "Kralastic for Product Engineering and Design" contains physical and chemical properties for the high-impact, moldable ABS plastics. Also included is design information on more than 20 molded products currently being made from this material. 28 pages. Naugatuck Chemical Div., United States Rubber Co., Naugatuck, Conn.

Circle 726 on Page 19

Pipe Connections

Catalog of pipe connections and accessories contains all new types and ratings of Grayloc clamps, collar-type unions, flanges, vessel nozzles, closures, and bleeder valves. Products with related applications are also catalogued, including bimetallic pipe and fittings. Ten-page table of allowable working pressures for pipe and connections from 1 to 30 in. to 1500 F is included. 44 pages. Gray Tool Co., P. O. Box 2291, Houston 1, Tex.

Circle 727 on Page 19

Control Knobs

More than 345 styles of control knobs for industrial and military use are shown in bulletin Product Data 5-110. All knobs meet new military specification MS91528B. Bulletin contains pictures, dimensional drawings, and tables. 8 pages. Industrial Components Div., Raytheon Co., 55 Chapel St., Newton 58, Mass.

Circle 728 on Page 19

Friction Materials

Standard friction parts are outlined, and characteristics and recommendations are given in Brochure 1051. Parts and materials listed are suitable for brakes, clutches, automatic transmissions, and vibration dampers regularly installed in automotive, construction, and industrial equipment, power tools, and consumer appliances. Design data cover size limits, tolerances, friction material descriptions, and recommended applications. Data also include tensile strength, coefficient of friction and recommended service for each type of material. 4 pages. World Bestos Div., Firestone Tire & Rubber Co., New Castle, Ind.

Circle 729 on Page 19

Positioning Control

Bulletin 500A shows how electrical-mechanical Hanna-Powr Positioner can be used to position many types of mechanical devices automatically at any of several predetermined positions corresponding to a remote control selector-switch signal. Visual flow action illustrations, line drawings, and charts provide specific information needed to plan ways of using the unit in air-hydraulic power cylinders, motorized screw drives, and other regulating devices. 10 pages. Hanna Engineering Works, Dept. PR-27, 1765 Elston Ave., Chicago 22, Ill.

Circle 730 on Page 19

Caster Selection

Essential information about five standard series of casters that fulfill most industrial requirements is provided in pocket-sized Catalog 1750. In tabular form, information on each of the series includes wheel diameter and face, model number, rated capacity, wheel type, over-all height, and bolt-hole spacing on swivel and rigid casters. Data on characteristics such as floor protection, nonmarking, and cushioning effects are also included. 16 pages. Rapids-Standard Co. Inc., 342 Rapistan Bldg., Grand Rapids 2, Mich.

Circle 731 on Page 19

Hydraulic Fittings

Bulletin 921 illustrates and describes frequently used hydraulic fittings in OEM design. Manual contains specifications on such products as adapter couplings, bushings, elbows, tees, hose assemblies, and brackets. Fold-out page shows diagrammatic views of Dryseal pipe threads and relationships of different types. Methods of Dryseal pipe-thread gaging are given, as well as definitions of series symbols, differences in pipe threads, and gaging practice for various pipe threads. 17 pages. Original Equipment Sales Div., Lincoln Engineering Co., 4010 Goodfellow Blvd., St. Louis 20, Mo.

Circle 732 on Page 19

Nonmetallic Alloys

Pocket-sized booklet, "Dynamic Ideas in Materials," describes company's various materials and products, particularly Fiberloys. Applications in such fields as electronics, electrical equipment, printing, automobiles, missiles, aircraft, data processing, and chemical processing are given. 12 pages. Rogers Corp., Rogers, Conn.

Circle 733 on Page 19

Plastic Products

Bulletin 611 explains typical applications of plastic products with controlled properties that can be manufactured to MIL specifications. Products include radomes, plastic antennas, parabolic dishes, microwave lenses, encapsulation and potting of electronic components, and structural plastic panels. Tables giving typical mechanical properties of glass-fiber-base polyester laminates and rigid polyurethane foam are included. 4 pages. Polystructures Inc., 41 Montvale Ave., Stoneham, Mass.

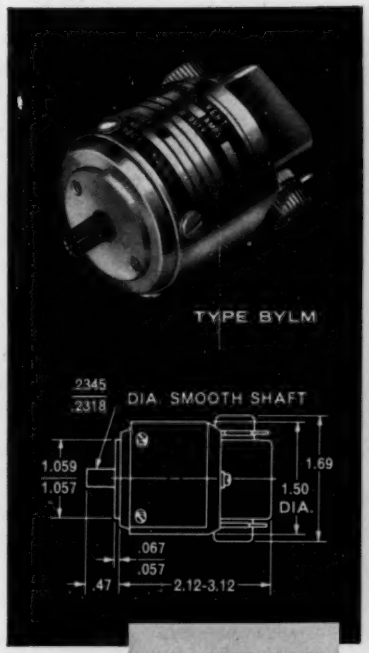
Circle 734 on Page 19

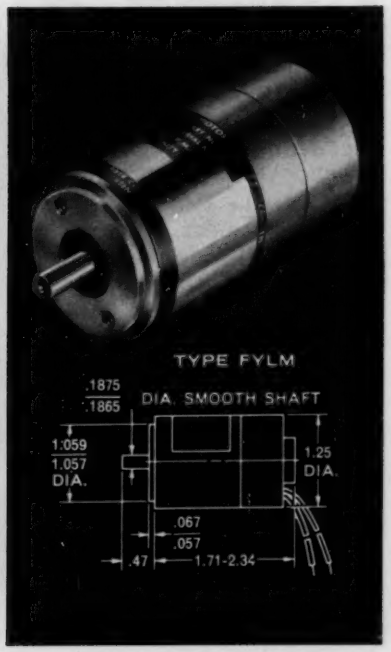
Thermal Insulation

Catalog 1N-244A completely describes thermal insulations for all types of commercial and industrial requirements in applications with temperatures from −400 to +3000 F. Six sections are each devoted to a specialized group of insulations. Information on each product consists of application photograph, description, available forms or types, list of advantages, and detailed specification data. 64 pages. Johns-Manville Sales Corp., 22 E. 40th St., New York 16, N. Y.

Circle 735 on Page 19

Permanent magnet, d-c tachometer generators with high linear output . . . low ripple . . . for precision applications





THE MARK OF QUALITY

BARBER COLMAN

UP TO 24 VOLTS PER 1000 RPM OUTPUT

RATED OUTPUT TOLERANCES WITHIN ±1.5%

3% MAXIMUM RIPPLE VOLTAGE (OVER 100 RPM)

STABILIZED MAGNETS

SELECTION OF OUTPUT SHAFTS AND MOUNTING FLANGES

Barber-Colman permanent magnet tachometer generators are available in two basic designs, shown above, with three frame sizes each. Type BYLM (1.50″ diameter) is capable of output voltages up to 24 v per 1,000 rpm. Type FYLM (1.25″ diameter) provides outputs to 10 v per 1000 rpm. With special modifications, higher output voltages can be obtained. Ruggedness characterizes both designs. Laboratory tests of standard units (operable from −65° F to +200° F) indicate a life expectancy of 2,000 hours at 3,000 rpm. Units have also been designed for +500°F ambient. Ask for Bulletin F-9581.

WRITE FOR NEW QUICK REFERENCE FILE on the complete line of Barber-Colman electrical components. Includes detailed specifications on a-c and d-c motors, tach generators, blowers, gearheads, relays.

BARBER-COLMAN COMPANY

Dept. O. 1873 Rock Street, Rockford, Illinois

Circle 513 on Page 19

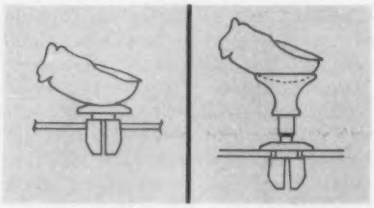
introducing

NYLATCH®

Nylatch, a new push-pull fastener, is now offered off the shelf to industry needing the ultimate in dependable low cost fastening.

Nylatch will replace most existing fasteners for metal, wood and synthetics yet gives these outstanding features—

- Less than 10 seconds installation—merely insert grommet into material to be fastened and insert plunger in grommet.
- Standard punched or drilled holes accommodate Nylatch.
- Nylatch allows up to .040 misalignment tolerance.
- Rugged two-piece construction gives 30,000 complete cycles of operation. Thoroughly tested for temperature, creep characteristics, fatigue and load.
- Versatility of design allows you a selection of plunger head designs. Available in wide range of decorator colors.



Press grommet into removable sheet

Press plunger into installed grommet

Your inquiry will bring complete information.

THE HARTWELL CORPORATION
9035 VENICE BOULEVARD, LOS ANGELES 34, CALIF.
Offices:
Chicago · Ft. Worth · Hackensack · Seattle · Wichita

Circle 514 on Page 19

HELPFUL LITERATURE

Thyratrons

Two new bulletins, "Thyratrons Are Different" (PA-223), and "The Care and Control of Thyratrons" (PA-503), discuss how thyratrons differ from high-vacuum tubes; ionization and de-ionization; temperature effects; installation precautions; dc control; ac control; and how to interpret thyratron ratings. Separate section on applications describes a remote-controlled switch, a welding timer, a motor control, and a power inverter. 4 pages each. Information Services, CBS Electronics, 100 Endicott St., Danvers, Mass.

Circle 736 on Page 19

Conveyor-Belt Selection

Guide to the correct selection of conveyor belts for food and package-handling applications is included in Brochure IPC-261-1. Belts are rated on a selector chart for characteristics such as resistance to abrasion, high temperatures, and oil and grease resistance. Featured in the section on food-handling belts are Koroseal and Green Pack belt constructions. 12 pages. B. F. Goodrich Industrial Products Co., Div., B. F. Goodrich Co., Akron, Ohio.

Circle 737 on Page 19

Molded Plastics

Form 1181-B covers glass-fiber-reinforced, custom-molded plastics and wood-chip material molded plastics. Large range and adaptability of molded Masterglas products is illustrated and explained. Mechanical and chemical characteristics are also listed. Another section is devoted to a description of Delwood, a formulation of cured wood products, glass fibers, and waterproof resins. 8 pages. Gisholt Plastics, 1245 E. Washington Ave., Madison 10, Wis.

Circle 738 on Page 19

Regulators, Control Valves

Bulletin J-DI or. ductile-iron regulators and control valves fully illustrates and describes Sliding Gate seats available in all company's regulators and control valves. Bulletin describes in detail the composition, properties, and specifications of ductile-iron valves. It includes a comparison table on steel, cast iron, and red brass versus ductile iron, and explains how ductile iron is able to replace steel in many applications at a cost reduction. OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio.

Circle 739 on Page 19

Acceleration Switches

"Donner Acceleration Switches for Dynamic Accuracy" examines the problem of meaningful accuracy in acceleration switches aboard operational missiles. Principles of operation and variations available in the line of switches are described. Pictures, table, and line drawings provide complete specifications. 6 pages. Donner Scientific Co., Concord, Calif.

Circle 740 on Page 19

NOW! DORMEYER PRESENTS "AMERICA'S FINEST SOLENOID LINE"

here it is—completely new—completely redesigned—the

DORMEYER SUPER-T-LINE

Check these new and improved features

- Heavier, Sturdier Mounting Brackets
- Extra Heavy, Well Supported Plunger
- High Seating Pull without excessive AC Hum
- High Dielectric Bakelite Bobbin
- Stainless Steel, Non-Rusting, Anti-Residual Spring
- Larger Contact Area between Co-acting Members for Longer Life
- Stronger, Heavy Gauge, Pull-Bar
- Moisture Resistant Coil
- Moisture Proofed or Epoxy Resin Encapsulated Coils available for High Humidity Conditions
- Design provides for Maximum Work without Power Drop-Off

More rugged, with greater designed-in and built-in dependability, the new Super-T deserves to be called "America's Finest Solenoid Line". Write for Catalog today!

DORMEYER INDUSTRIES
FACTORIES IN CHICAGO AND KENTLAND, INDIANA

Also Builders of Special Coils and Transformers

3434 Milwaukee Avenue • Chicago 41, Illinois

Circle 515 on Page 19

Computers and Accessories

"New Solutions in the Science of Simulation" details the latest advances in computer technology and equipment. Included is a report on the 5800 Dystac, a computer which combines the analog computer's features with those of the digital computer to provide many advantages. Brochure also lists line of precision products and components used as accessories to central computer consoles and also for other applications. Several applications in various industries are shown. 20 pages. Computer Systems Inc., Culver Road, Monmouth Junction, N. J.

Circle 741 on Page 19

Semiconductor Bases

Line of stud-mounted semiconductor bases and mating caps is reviewed in Form 2714. Principal purpose of the literature is to detail functional advantages stemming from the precision cold forming, and from special thread rolling, gaging, and plating techniques used in manufacture of the units. Critical dimensional tolerances, as close as 0.001 in. on flatness of certain surfaces, are detailed. 4 pages. Box 102, Standard Pressed Steel Co., Jenkintown, Pa.

Circle 742 on Page 19

Accelerometers

Technical Bulletin T-105 illustrates and describes a line of true compression-type accelerometers designed for applications in missile and airborne-vehicle shock and vibration study. Eight different models of accelerometers, and a calibration reticle, developed for quick calibration of vibration equipment, are described. Bulletin includes all electrical and physical specifications. 2 pages. Columbia Research Laboratories, MacDade Blvd. & Bullen Lane, Woodlyn, Pa.

Circle 743 on Page 19

Pushbutton Stations

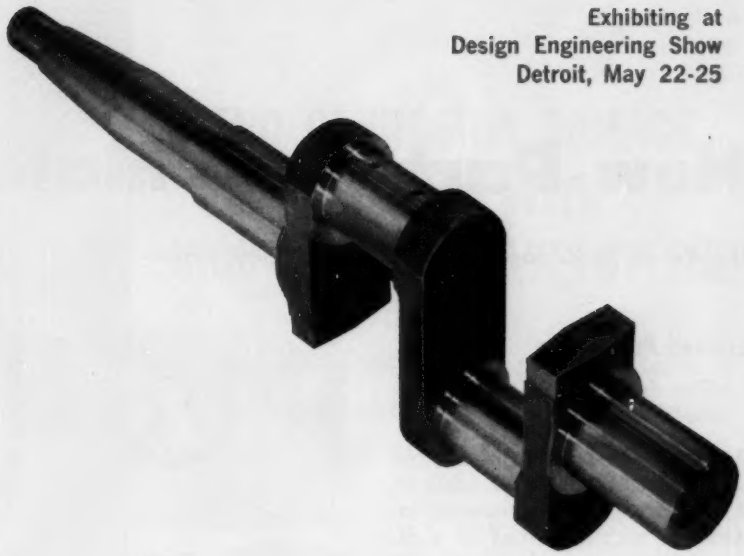
Bulletin GEA-6544A discusses line of pushbutton stations for standard and heavy-duty applications. Publication includes photographs of standard units and stations, diagrams showing dimensions, and ordering information. Photograph with call-outs explains features of the heavy-duty pushbutton station. Also shown are typical applications of various stations. 8 pages. General Electric Co., Schenectady 5, N. Y.

Circle 744 on Page 19

Miniature Connectors

Comprehensive Catalog 20-1060 describes rectangular plug-and-socket connectors designated Series 20. Complete description, electrical and mechanical specifications, and ordering information are included. All units are illustrated in photographs and dimensional drawings. 44 pages. Write on company letterhead to Electronic Sales Dept., DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Exhibiting at
Design Engineering Show
Detroit, May 22-25



RIGIDITY

A CASE IN POINT—This seventy pound ductile iron crankshaft is made for compressors manufactured by The Brunner Division of Dunham-Bush, Inc. The increased loads and speeds called for by new compressor design specifications required rigidity and strength beyond the limits of the cast iron alloy shafts formerly used. Ductile iron was chosen because the rigidity, tensile strength, fatigue strength and wear characteristics comfortably exceed operating requirements. A major bonus—the existing pattern equipment could be used for the ductile iron castings, thus saving the high cost of dies needed for steel forgings.

Ductile iron has most of the engineering advantages of steel yet it can be designed with the same flexibility and cast with the same procedures as gray iron. The 120-90-02 grade used in this case has an elastic modulus of about 24 x 10^6 psi, 42,000 psi endurance limit, and 300 BHN. The 120,000 psi tensile strength is double that of the previous crankshaft. Hamilton Foundry regularly casts all grades of ductile iron and high alloy Ductile Ni-Resist.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules—will be met.

GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD

HAMILTON FOUNDRY INC.

1551 LINCOLN AVENUE • HAMILTON, OHIO • TWinbrook 5-7491

Circle 516 on Page 19

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Lighted Pushbutton

offers single or two-color indication

Miniaturized lighted pushbutton switch is 0.812 x 0.890 x 1.303 in. Switch offers single or two-color indication, with each half of a divided display screen having its own individual light source. Five colors are available for the display screens, so that a single switch can have any of 15 color combinations. Unit is designed for control equipment,

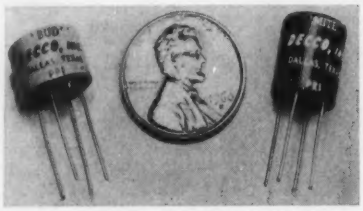
computers, industrial, and commercial applications where visual control indication is required. Switch contains two single-pole double-throw subsubminiature switch elements rated at 7 amp resistive and 25 amp maximum inrush at 24 v dc; 7 amp resistive and 15 amp inrush at 115/230 v ac. Spring clips permit quick insertion and removal from mounting holes. **Micro Switch Div., Minneapolis Honeywell Regulator Co., Freeport, Ill.**

Circle 745 on Page 19

Transistor Transformers

for rapid printed-circuit board mounting

Two miniaturized transistor transformers, identified as Buds and Mites, are encased in drawn-steel cans with nickel-alloy leads on standard 0.1-in. spacings for rapid printed-circuit-board mounting. Bud is only 5/16 in. high and Mite has



3/8 in. diam. Total of 42 designs can be supplied in either style as standard units, and other variations are available on special order. **Decco Inc., 2025 Farrington, Dallas, Tex.**

Circle 746 on Page 19

Vinyl Magnetic Strip

is now available in colors

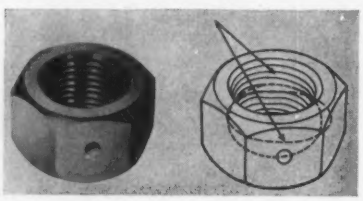
Koroseal vinyl magnetic strip, previously available only in basic brown, is produced in nine standard colors and can be manufactured to meet any color specification. Vinyl paint coating becomes an integral part of the magnetic strip. Surfaces are nonstaining, can be wiped clean with a damp cloth, are nontoxic, and color-constant. Color includes white, black, yellow, orange, red, and two shades each of blue and green. **B. F. Goodrich Industrial Products Co., Akron, Ohio.**

Circle 747 on Page 19

Two-Way Lock Nut

is ovalized to give 180-deg spring

Reusable, double-chamfered lock nut is designed for automatic application. Locking device of the nut is in the body of the nut so



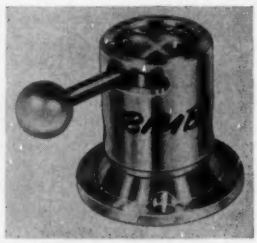
that greater locking power is assured when nut is mounted flush with end of bolt or when all threads are not used. Nut is ovalized to give 180-deg spring, and threads are deflected at point of lock so that nut can be locked in any position. Sizes No. 5 through 1 1/4 in. are available. **MacLean-Fogg Lock Nut Co., 5535 N. Wolcott Blvd., Chicago 40, Ill.**

Circle 748 on Page 19

Air Valves

base-mounted units are only 1 13/16 in. high

Three and four-way air valves have full 1/8-in. ports. Low-priced valves contain 1/8-in. NPT air connects, are base mounted, and only 1 13/16 in. high. Three-way valve is designed to be used with a single-acting air cylinder, and four-way unit with a double-acting air cylinder. All working parts can be



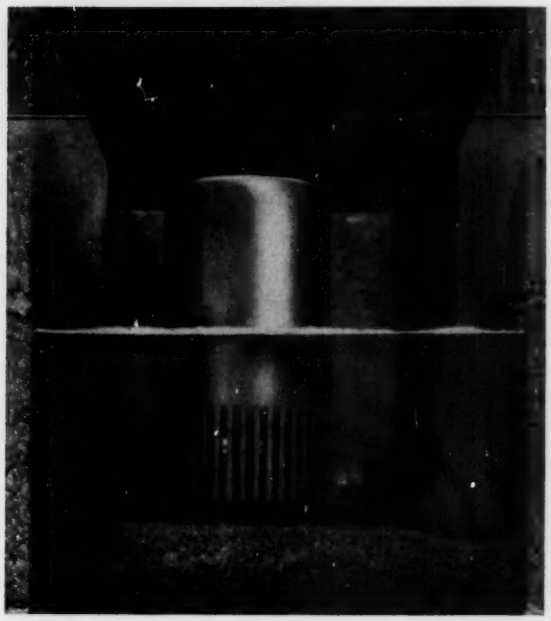
replaced without removing valves from line. **Bimba Mfg. Co., 101 Main St., Monee, Ill.**

Circle 749 on Page 19

Adjustable Cam Assemblies

miniature units have pin or clamp-type hubs

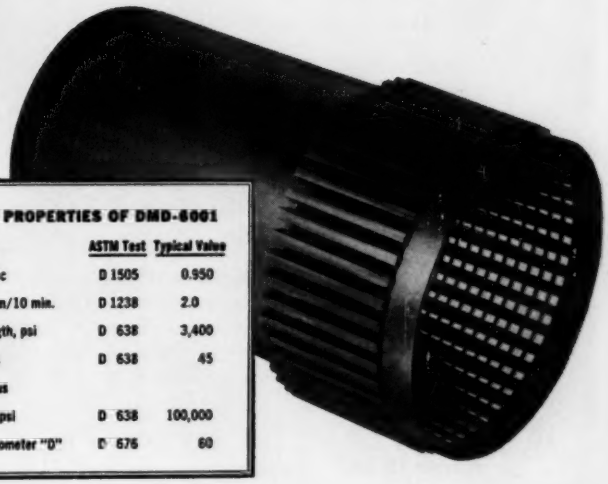
Miniature adjustable cam assemblies, designed for use in all precision timing applications, feature positive locking at any predetermined operational setting within a



END CORROSION DAMAGE ...DESIGN WITH HIGH-DENSITY POLYETHYLENE

BAKELITE BRAND high-density polyethylene gives 100% corrosion resistance with strength and molding ease

Strong Plastic Housing for Sump Pump—Fostoria Corporation's "Dynasumps," designed for rigorous underwater service, are housed in covers molded from BAKELITE Brand high-density polyethylene DMD-6001. The cover-strainers are deep-drawn molded in one piece by Haas Corporation.

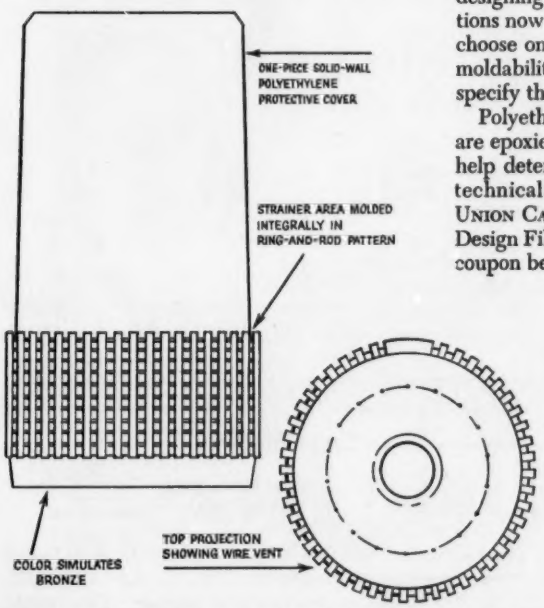


Nothing to Corrode in This Cover—One-piece molding provides neat, tight-fitting cover with no screws, bolts, or nuts to vibrate, work loose or corrode. Drainage water and chemical detergents have no adverse effect on this completely corrosion-resistant component.

TYPICAL PROPERTIES OF DMD-6001

Properties	ASTM Test	Typical Value
Density, gm/cc	D 1505	0.950
Melt Index, gm/10 min.	D 1238	2.0
Tensile Strength, psi	D 638	3,400
Elongation, %	D 638	45
Secant Modulus (Stiffness), psi	D 638	100,000
Hardness, Durometer "D"	D 676	60

Easy to Mold, Tough in Service—Toughness and rigidity are characteristics of parts molded from BAKELITE Brand high-density polyethylene. Molding ease and flexibility go far in eliminating many common production problems. Result: a durable, smooth-functioning part that is resistant to water and most common chemicals.


ONE-PIECE SOLID-WALL POLYETHYLENE PROTECTIVE COVER
STRAINER AREA MOLDED INTEGRALLY IN RING-AND-ROD PATTERN
COLOR SIMULATES BRONZE
TOP PROJECTION SHOWING WIRE VENT

Finding the right combination of properties needed in the product you're designing is made easier by the variety of BAKELITE polyethylene formulations now available. In addition to low, medium and high densities, you can choose one of the new polyethylene copolymers. Stress-cracking resistance, moldability, dimensional stability, toughness, flex life, rigidity—you can now specify the properties you require.

Polyethylenes are only one group of BAKELITE Brand plastics—the others are epoxies, phenolics, styrenes, and vinyls—from which you may select. To help determine the one you could use to your best advantage, call on the technical experience and know-how of UNION CARBIDE. Consult Sweet's Product Design File, section 2a/ui. Or just mail the coupon below.

UNION CARBIDE

Union Carbide Plastics Company (Dept. KQ-84C)
Division of Union Carbide Corporation
270 Park Avenue, New York 17, N. Y.

Please send me information about BAKELITE Brand Plastics for Design, with emphasis on these properties:

_____

The type of application being considered is:

NAME _____

FIRM NAME _____

STREET _____

CITY _____ ZONE _____ STATE _____

BAKELITE and UNION CARBIDE are registered trade marks of Union Carbide Corporation.

FREE reprints from MACHINE DESIGN

Limited supplies of the following reprints of articles which have appeared in MACHINE DESIGN are still available at no cost. Circle the ones you want on the order form below and mail to Reader Service, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

1 How to Select and Apply TIMERS by W. B. Shinn, September 1, 1960 (18 pages)

2 Selecting and Specifying ORGANIC FINISHES by R. G. Murphy, June 9, 1960 (12 pages)

3 CHOOSING THE RIGHT COLOR by Faber Birren, August 6, 1959 (7 pages)

4 CRITICAL SPEEDS SIMPLIFIED by F. F. Ferrary and John E. Nelson, August 18, 1960 (2 pages)

5 DESIGNING WITH VINYLS by C. W. Bulkley, August 18, 1960 (13 pages)

6 How to Use FUNCTIONAL TOLERANCING by Reginald E. Stanley, September 1, 1960 (7 pages)

7 How to MULTIPLY YOUR EFFECTIVENESS as an Engineer by Philip Marvin, October 13, 1960 (7 pages)

8 SHELL-MOLD CASTINGS for Complex Shapes, Smooth Surfaces and Intricate Coring, March 7, 1957 (7 pages)

9 Charts and Equations for a Simplified Approach to HELICAL-SPRING DESIGN by J. Hirschhorn, February 19, 1959 (5 pages)

10 DESIGN OF HELICAL SPRINGS by Ray C. Johnson, September 18, 1955 (6 pages)

11 DESIGNING WITH NYLON by A. J. Cheney, March 8, 1956 (7 pages)

12 IDLER GEARS by Thomas Barish, November 28, 1957 (5 pages)

13 ELECTRIC MOTOR SELECTOR by MACHINE DESIGN's Staff, July 24, 1958 (10 pages)

MACHINE DESIGN READER SERVICE

Penton Building
Cleveland 13, O.

Send reprints without charge as circled below.

1 2 3 4 5 6 7
8 9 10 11 12 13

NAME TITLE

COMPANY

ADDRESS

CITY ZONE STATE

F-61

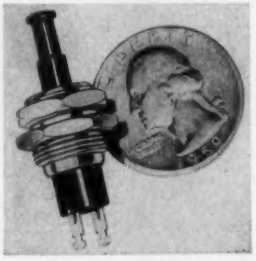
range of 0 to 180 deg. Machined from No. 303 stainless steel with clear passivated finish, assemblies are stocked in 0.1248, 0.1873, and 0.2498-in. bore sizes, in pin or clamp-type hub styles. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, L. I., N. Y.

Circle 750 on Page 19

Miniature Switch

for ½-in. mounting hole

No. 30-16 push-pull switch with a life expectancy of over 100,000 cycles is 1.492 in. long. Available for ½-in. mounting hole, it has a "positive-feel" detent action with an audible click. Switch is maintained in either position until sufficient actuating force is applied in the opposite direction. It is a push-on, pull-off action, single-pole, single-throw, normally open unit with butt contact. Switch is rated at 1 amp, 115 v ac resistive, contact re-



sistance 0.010 ohm. Base and button are molded phenolic. **Grayhill Inc.**, 561 Hillgrove Ave., LaGrange, Ill.

Circle 751 on Page 19

Servo Motor

has no-load speed of 10,000 rpm

Tiny Size 5 servo motor is designed for applications calling for minimum size and weight. Designated

In this 1960 LEWYT Vacuum Cleaner, Flexible Tubing does two important jobs: (1) it carries dirt, (2) it conducts electricity

Proof that today's designers can make Flexible Tubing do almost anything

In the new Lewyt Vacuum Cleaner, Model 121, a motorized head revolves brushes that beat out and sweep up the dirt. How to get power to this Motorized Beater Sweeper — without unsightly wiring — posed a problem.

Solution: Flexible Tubing's "Vac-U-Flex" vinyl hose. It carries the dirt — and conducts the current through a unique double-coil wire reinforcement *inside* the hose wall. Neat . . . simple . . . efficient — and styled to match the machine. Perfect example of the design versatility you get with Flexible Tubing!

Whenever the handling of air, liquids or light solids is a design problem, there's a Flexible Tubing product that can do the job! You can choose fabrics, coatings and sizes to fit your specifications.

Flexible Tubing is at work today in diesel engines, electronic computers, farm combines, television transmitters and hundreds of other places. To find out what Flexible Tubing can do for you, just mail the coupon.

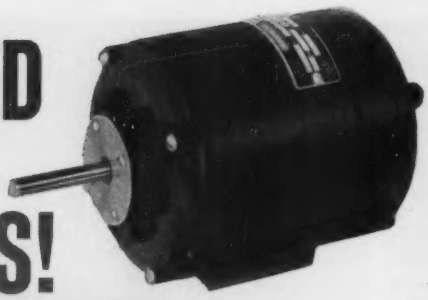
Flexible Tubing
CORPORATION
Anaheim (Los Angeles) • Guilford, Connecticut
Hillside (Chicago)

Flexible Tubing Corporation,
63 New Whitfield Street, Guilford, Conn.
Gentlemen:

I'm designing a new product ☐ I'm redesigning an old one ☐
One of my problems is the handling of air ☐ liquids ☐ light solids ☐ Could be Flexible Tubing can help me solve them. I'll give you 10 minutes to show me, to prove it. Phone for appointment ☐ No problems right now. Send me literature for my files ☐

NAME .....
COMPANY .....
ADDRESS .....
CITY ..... STATE .....

MACHINED MATING SURFACES!



HOWARD

UNIVERSAL & DC
29-500 MOTOR
1/12 TO 1/4 H.P.

The Ultimate in Universal Motor Quality— at Lowest Cost Available!

So fine a motor, all mating surfaces are **machined**—not die-cut—for closest possible tolerance! Assures uniformity of air gap for minimum cogging, uniform output. For communications, hospital, dental, metering and hydraulic pump equipment, computors and other applications.

Write today for complete details!

DIAM. 3⅛" **LENGTH** 4¹¹⁄₁₆" to 5¹¹⁄₁₆"
H.P. Continuous:
Series—1/6 @ 10,000 RPM
Shunt or Compound—1/12
Intermittent:
Series—1/4 @ 10,000 RPM
Shunt or Compound—1/6
SPEED:
No Load: Series—15,000 RPM
Shunt or Compound—12,000 RPM
Full Load: Series—3,000 to 10,000 RPM
Shunt or Compound—1,000 to 10,000 RPM
VOLTAGES:
Series—6 to 250V AC/DC
Shunt or Compound—6 to 230V DC

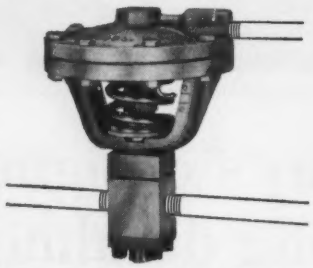
Divisions: (EMC) Electric Motor Corp. (CES) Cyclohm Motor Corp. (LS) Loyd Scruggs Co.

HOWARD INDUSTRIES, INC. • 1735 State Street • Racine, Wisconsin

Circle 520 on Page 19

G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL

POSITIVE CONTROL FOR PROBLEM FLUIDS!



If suitable barstock material is available, any problem fluid can be throttled or provided with positive on-off control. Dahl BANTAM Control Valves, featuring barstock bodies, handle any chemical fluid except liquid metals like sodium and similar fluids where excessive temperature is a restriction.

BANTAM features include excellent flow characteristics, low hysteresis, and fast response. Offered in a wide selection of pneumatic operators and control positioners, standard models are rated at pressures up to 1000 psi at 450°F. Compactness, quality construction, and ruggedness also contribute to their virtually unlimited application versatility.

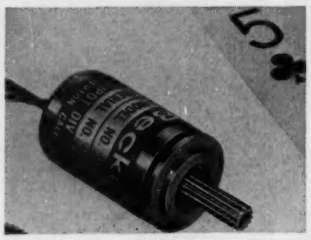
REQUEST Catalog B-1 for complete data on these versatile valves . . . for positive control of your problem fluids! G. W. Dahl Co., Inc., 83 Tupelo Street, Bristol, Rhode Island.

G. W. DAHL CO., INC.

SPECIALISTS IN COMPACT VALVES AND CONTROLS

G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL

G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL • G. W. DAHL



Model 9005-1502-0, unit is 0.865 in. long and weighs 0.6 oz. Powered by 26-v, 400-cycle reference voltage, motor has a no-load speed of 10,000 rpm. Torque at stall registers 0.1 oz-in., while rotor inertia is 0.18 gm-cm², providing an acceleration at stall of 39,000 rad per sec per sec. Stainless-steel bearings, shaft, and housing, and use of Teflon for insulation, permit operation over an ambient temperature range of −55 to +130 C. **Helipot Div., Beckman Instruments Inc.**, 2500 Fullerton Rd., Fullerton, Calif.

Circle 752 on Page 19

Germanium-Alloy Transistors

for operation in −65 to +85 C temperatures

New series of PNP germanium-alloy transistors is available for applications requiring high gain and low - noise characteristics. The 2N1175 and 2N1175A low-noise devices have minimum collector-to-base voltage ratings of 35 v, collector-to-emitter minimum ratings of 25 v, and minimum emitter-to-base voltage ratings of 10 v. Units have a typical collector-cutoff current of 6 ma with a collector-to-base voltage of 30 v. Devices are rated for operation in −65 to +85 C temperatures. **Semiconductor Products Dept., General Electric Co.**, Kelley Building, Liverpool, N. Y.

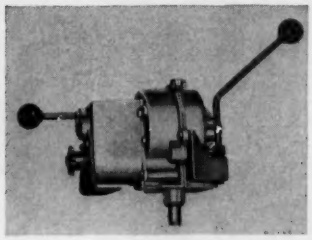
Circle 753 on Page 19

Two-Speed Transmission

can be mounted in any position

Right-angle reversing transmission with two speeds forward, plus reverse and netural, Model P-334 is compact and weighs approximately 14 lb. It can be mounted in any position. Lubricated with a high-temperature grease, unit is virtually

leakproof. Reduction in high speed is 2:1 and in low, 3.4:1. Maximum recommended input speed is 1800 rpm. Forward, neutral, and reverse are controlled by shifter lever incorporated in right-angle half of the transmission. Primarily designed for use on riding rotary lawn mowers using vertical engines with capacities to 5½ hp. Transmission is available with variations in assembly and components for use in other ap-



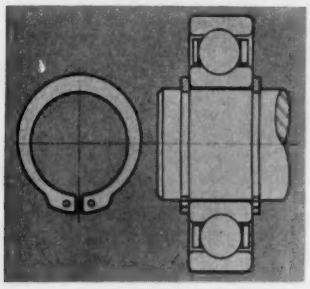
plications. **J. B. Foote Foundry Co.**, P. O. Box 2214, Ft. Dearborn Station, Dearborn, Mich.

Circle 754 on Page 19

Retaining Ring

has high thrust load and impact resistance

Truarc Series 5160 heavy-duty, external-type retaining ring is designed for assemblies subjected to extreme loading conditions. Ring has high thrust load and impact resistance and provides a high shoulder to retain parts having large corner radii or chamfers. It can be used without spacer washers to secure ball bearings, tapered roller bearings, and cylindrical roller bearings. Ring can also be used to replace heavy-duty nuts, machined shoulders, and other bulky fastening devices used to secure components on shafts, axles, and similar structural members. Ring currently is available in 11 sizes



(*Please turn to Page* 210)

the hallicrafters co.

Leading Manufacturer of Electronic Equipment Reports . . .

Left to Right: Jim Lawless, Hallicrafters' Chief Draftsman; Mark Pogue, Reproduction Department Head; Frank Krautsak, Bruning Representative.

"Bruning helps, *two ways*, to meet Tight Government Deadlines!"

"It's the *extras* we get from people and equipment that help us meet tight government QRC* contract deadlines," says Jim Lawless, Hallicrafters' chief draftsman. "Bruning products and service are good examples. We've run our Copyflex reproduction machines an average of 77 hours a week. Yet, we've never had a delay because of machine failure, maintenance, or lack of materials. Another big extra has been the help of the Bruning Representative who has saved us many hours of work with everything from intermediates to electric erasers."

Why not make Hallicrafters' experience your basis for investigating Bruning?

*Quick Reaction Capabilities.

BRUNING

Charles Bruning Company, Inc. Dept. 3-W
1800 Central Rd., Mt. Prospect, Ill.
Offices in Principal U. S. Cities
In Canada: 103 Church St., Toronto 1, Ont.

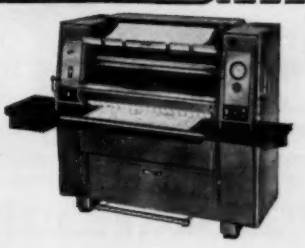
Please send me information about your reproduction and drafting products and service.

Name_____ Title_____

Company_____

Address_____

City_____ Co._____ State_____



Circle 522 on Page 19

NEW SUPER-TOUGH ORE HAULER USES

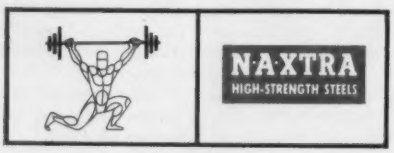
N-A-XTRA

HIGH-STRENGTH STEEL TO CUT DEAD WEIGHT AND STRETCH PAYLOAD CAPACITY

This Lectra Haul M-55, made by Unit Rig and Equipment Co. of Tulsa, is now working in the open pit iron mines in Minnesota's Mesabi range. In bone-freezing —40° weather, it can stand up to the shuddering shock of 55 tons of drop-loaded iron ore, climb a 6% grade at 8.6 mph then dump those 55 tons in a crashing, grinding 18 seconds. The quarry body that takes this loading impact and dumping abrasion in sub-zero temperatures is made of N-A-XTRA high-strength steel, with X-A-R Abrasion Resistant Steel for extra hardness and toughness in wear areas. N-A-XTRA also forms the structural members of the complete unit.

Why N-A-XTRA? Because, pound for pound, it's nearly three times stronger than ordinary steel. That means it's strong enough to absorb severe punishment without constant maintenance, and light enough to handle the highest possible payload. In fact, the Lectra Haul payload is almost as much as the net vehicle weight itself.

N-A-XTRA and X-A-R are doing the job where only the strongest steels will do. Easily formed and welded, they are making products stronger, lighter, longer lasting. N-A-XTRA fully quenched and tempered steel is available in four levels of minimum yield strengths, from 80,000 to 110,000 psi. X-A-R steels are supplied in hardnesses from 360 to 400 BHN (or, by agreement, in a range between 265 and 500 Brinell). For full technical information, write Great Lakes Steel Corporation, Product Development, Dept. MD-1, P.O. Box 7310, Detroit 2, Michigan.



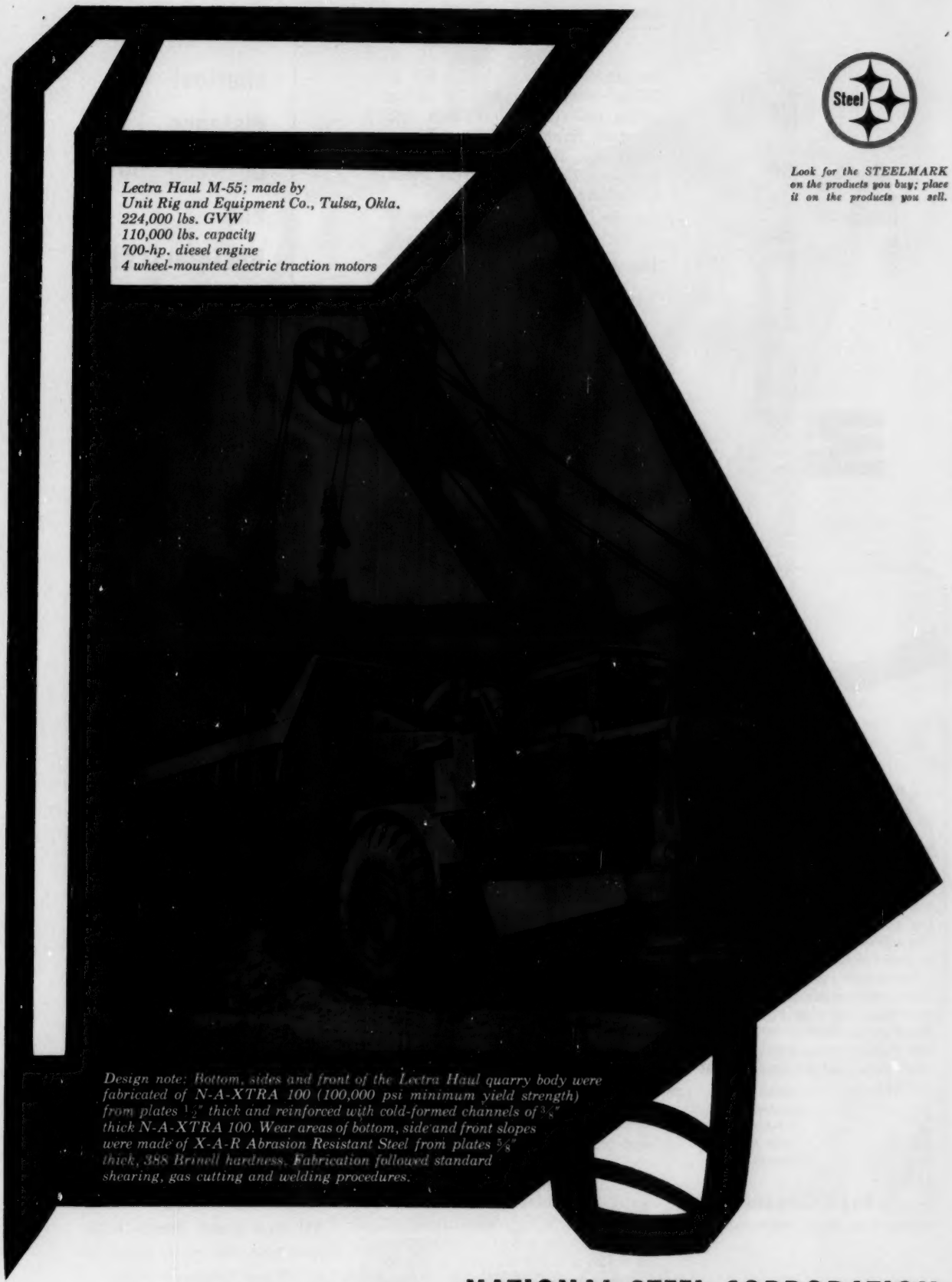
A PRODUCT OF

GREAT LAKES STEEL

Detroit 29, Michigan

N-A-XTRA AND X-A-R STEELS ARE AVAILABLE AT THESE STEEL SERVICE CENTERS

Benedict-Miller, Inc. Lyndhurst, New Jersey	Joseph Demsey Co. Cleveland, Ohio	Ducommun Metals & Supply Co. Los Angeles, California
Interstate Steel Co. Evanston, Illinois	Lockhart Iron & Steel Co. Pittsburgh, Pennsylvania	Marsh Steel & Aluminum Co. Kansas City, Missouri
O'Neal Steel, Inc. Birmingham, Alabama	Salt Lake Hardware Co. Salt Lake City, Utah	A. C. Leslie & Company, Ltd. Montreal, Canada



Lectra Haul M-55; made by
Unit Rig and Equipment Co., Tulsa, Okla.
224,000 lbs. GVW
110,000 lbs. capacity
700-hp. diesel engine
4 wheel-mounted electric traction motors

Design note: Bottom, sides and front of the Lectra Haul quarry body were fabricated of N-A-XTRA 100 (100,000 psi minimum yield strength) from plates ½" thick and reinforced with cold-formed channels of ⅜" thick N-A-XTRA 100. Wear areas of bottom, side and front slopes were made of X-A-R Abrasion Resistant Steel from plates ⅝" thick, 388 Brinell hardness. Fabrication followed standard shearing, gas cutting and welding procedures.

Steel

Look for the STEELMARK on the products you buy; place it on the products you sell.

***Great Lakes Steel is a Division of* NATIONAL STEEL CORPORATION**

THE FREE MODEL DIMENSION

. . . saves 35 machining operations

This target revolver barrel is now being made by the new Hitchiner Ceramic Shell technique of investment casting. *Thirty-five* machining operations are eliminated! The only external finishing required is partial polishing.

Investment casting may provide many benefits for you . . . choice of alloy . . . flexibility of design . . . improved parts performance . . . reduction of costs. Maybe one of your parts can be made better for less.

Write for complete technical and facilities information.

HITCHINER
Milford 3, New Hampshire

Circle 524 on Page 19

(Continued from Page 207)

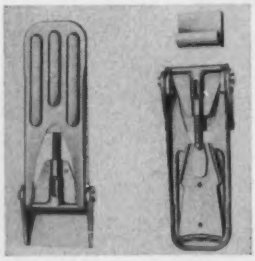
for shaft diameters from 0.473 to 2.0 in. Standard material is carbon spring steel (SAE 1065-1090), and standard finish is oil-dip. **Truarc Retaining Rings Div., Waldes Kohinoor Inc.**, 47-16 Austel Place, Long Island City 1, N. Y.

Circle 755 on Page 19

Universal Tension Latch

provides up to ½ in. adjustment

Adjustable - drawhook, universal-tension latch, designated 46L, 14 & 23, is used on reusable shipping containers, transit cases, and for other general purpose latch requirements. It provides up to ½ in. adjustment with an ultimate tensile strength of 1000 lb. Type 46L, 14 & 23 is completely interchangeable, model for model, with fixed drawhook latches. Common pivot of both drawhook and handle prevents accidental opening due to vibration and shock or buckling and misalignment of container sections. When latch is fully open, drawhook stows flat within the handle to protect it against damage during loading. **Camloc Fastener Corp.**, 37 Spring Valley Rd., Paramus, N. J.



Circle 756 on Page 19

Silicon Readout Photocells

read 10,000 characters per sec

Silicon readout photocells provide response time of 5 to 20 mu sec and read 10,000 characters per second in perforated tape and punched-card data-reading systems. Cell series is available with five, six, eight, nine, or ten readout positions, with an active cell area per segment of 0.128 x 0.067 in. and center-to-center spacing of 0.087 in. Typical current generated is 350 mu amp

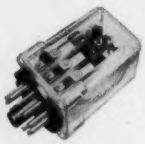
shortest distance between you and RELIABILITY!

LINE ELECTRIC CO.
division of
INDUSTRIAL TIMER CORPORATION

RELAYS
FOR EVERY APPLICATION
Factory Tested for Reliability!

GENERAL PURPOSE Open Type Relay. Up to 3PDT, 5 or 10 amp contact rating. Voltages up to 230 volts, AC or DC. Details in Bulletin 10.

GENERAL PURPOSE Plug-In Type Relay. Contact arrangements up to 3PDT. 5 or 10 amp contact rating. Voltages up to 230 volts, AC or DC. Details in Bulletin 10.



PRINTED CIRCUIT Open Type Relay. Up to 3PDT. 5 or 10 amp contact rating. Voltages up to 230 volts, AC or DC. Details in Bulletin 11.

LINE ELECTRIC CO.
division of INDUSTRIAL TIMER CORPORATION

211 River Street, Orange, N. J.
Industrial Relays, Foot Switches, Buzzers, Coils
Phone: ORange 2-8200

Circle 525 on Page 19

New

ROTO MISSION®

PATENTED

Most versatile transmission ever developed!

ONLY ROTO-MISSION GIVES YOU ALL THESE FEATURES

- Concentric configuration
- Minimum size for a specified torque
- Reduction ratios up to 270:1
- Optional torque capacities for each reduction ratio
- Torques up to 21,850 lb.-ft.
- Requires neither driving pulley nor coupling
- Casehardened helical gears—ground after hardening for perfect engagement
- Reversible
- Progressive overload capacity to the extent that no breakage of gears can result even from the severest abuse
- *Ability to engage or disengage driving action —mechanically, pneumatically, hydraulically or electrically
- *Ability to provide load releasing, load limiting or overload alarm
- *Ability to provide 2-speed operation

*Standardized accessories to provide these features are available for all sizes of Roto-Mission from stock. This results in a single responsibility for installation performance.

This new rotary transmission design combines a wide range of reduction ratios, high torque capacities, and excellent space-saving characteristics to give you more application versatility than ever before possible. It is designed to be concentrically mounted on a machine drive shaft in place of the drive pulley and operate this shaft at a reduced speed from that of the driving motor. For maximum compactness and convenience, all its parts are inside the casing.

The standard accessories available for each model of Roto-Mission add even greater versatility. Through them you have systems—from a single source—capable of control functions that previously required a number of unmatched units from several suppliers.

Because of its versatility and sound engineering, Roto-Mission permits you to solve design problems far beyond the range of other transmissions —may even permit incorporation of features in your machines that have not previously been possible. For complete information on this new product—how it operates and how it can help you —write today for catalog IR-61.

AIRBORNE®

Engineered Equipment for Aircraft and Industry

AIRBORNE ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY • Offices in Los Angeles and Dallas

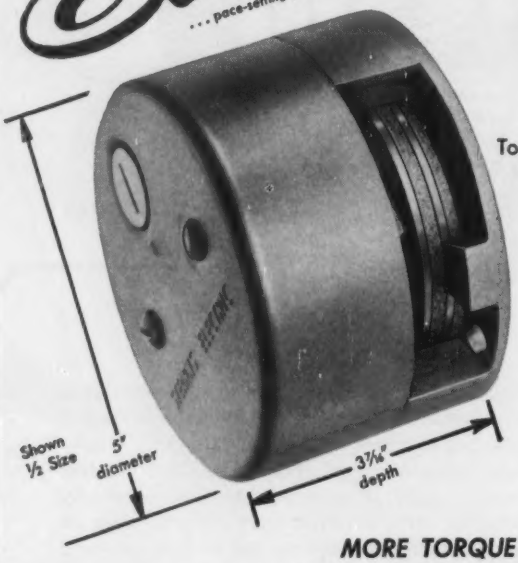
...and— another NEW product from Stearns

...pace-setting pioneer in electro-magnetic clutches—brakes—clutch-brakes

NOW AVAILABLE-
NEW SIZE H-44
electro-magnetic
DISC BRAKES

Prompt Shipment

Torque—3 lb-ft. max.
Weight—5½ lb



Exclusive *Stearnetic* unitized construction, and *"Visi-Wear-Indicator"*

MORE TORQUE PER POUND...
MORE TORQUE PER CUBIC INCH!

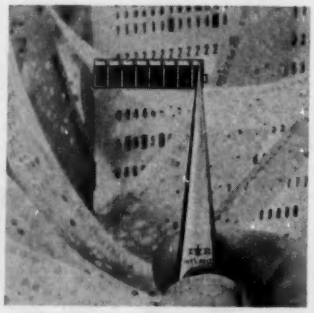
THE NEW STEARNS "H-44's" are spring set—solenoid released disc brakes that mount on NEMA "C" flanges of "40 frame" fractional hp electric motors . . . provide fast, smooth, quiet stops—"failsafe" operation . . . combine higher torque with minimum size and weight.

THE NEW STEARNS "H-44's" are available for either AC or DC . . . in Standard, or Dustight-Waterproof enclosures . . . operate horizontally or vertically . . . are also available with brackets for floor mounting.

Specify THE NEW STEARNS "H-44's" with complete confidence—they have been fully life-tested, and *Installation-Proved* for long, trouble-free, dependable operational life with a minimum of maintenance.

Request Stearns New Product Preview 1-61-B

Stearns ELECTRIC CORPORATION
120 NORTH BROADWAY • MILWAUKEE 2, WISCONSIN
The Complete Line of Electromagnetic Clutches — Brakes — Clutch-Brakes
SINCE 1917-THE CHOICE OF LEADING MOTOR AND MACHINERY MANUFACTURERS



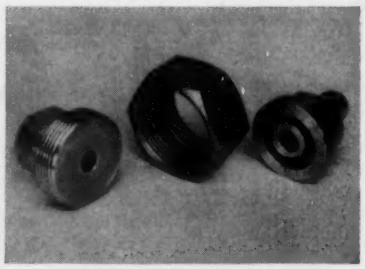
for 0.01 sq-in. of active cell area of 1000 ft-c illumination. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif.

Circle 757 on Page 19

O-Ring Seal Fittings

for use at temperatures from −20 to +275 F

High-pressure, O-ring seal-type fittings are available for leakproof, 6000-psi water, oil, and gas service. Use of O-rings as a static seal assures positive sealing and eliminates leakage. Hand-tightening of unions provides reliable performance at temperatures from −20 to 275 F. Sizes range from ¼ to 2½ in., both tube and pipe sizes, for tailpieces and mating thread pieces. Fittings are available in stainless steel and other materials, in female and male pipe and socket-weld configurations. They are also furnished to meet MS



33514, AND 10050, and AND 10056 specifications with union nuts to match. **Kahn & Co. Inc.**, P. O. Box 516, Hartford 1, Conn.

Circle 758 on Page 19

O-Ring Knob

seals tubes with OD of 0.080 to 0.120 in.

Miniature O-ring knob is available for use as an adjusting knob on sealed precision instruments such

this FREE sample kit is filled with product protection ideas for you

CAPLUGS DIVISION, PROTECTIVE CLOSURES CO., INC.
2201 Elmwood Ave., Buffalo 23, N. Y.

MAIL a free assortment of Caplugs, literature and prices to us, without obligation.

Name_____

Title_____

Firm_____

Address_____

City_____ Zone____ State_____

Circle 528 on Page 19

molded of tough, flexible Polyethylene

quickly applied . . . and removed

won't chip, break, shred, or collapse

extremely kind to threads

Caplugs

The modern way to protect tubing, threaded fittings and machined parts in storage, process and transit . . . over 600 sizes in numerous styles now in stock.

You can be sure of Uniform Performance from O-M Cylinders

Internal Key Tie-Rodless Type Series 101A. Air—150 psi—up to 1500 psi Hydraulic. Fits where others won't. Bulletin 101A.

Whether you operate O-M Cylinders, of the same psi rating, bore and stroke, singly or in sequence, each one will exert the same force, handle the same work load, with the same precision. In addition, the direction of each stroke, length of each stroke as well as the time interval between cycles will be controlled to the same high degree of accuracy. As all parts and mounts of O-M Cylinders, of the same capacity, are micro-honed or accurately machined to the same close tolerances, they are interchangeable and precise. Uniform operation is automatic.

O-M Cylinders are available in a complete range of sizes (1½" to 8" bores) with standard or heavy-duty rods. Complete line of interchangeable parts and mounts. Immediate delivery on most sizes.

Coupon below will bring our latest bulletins showing construction and dimensional details, engineering drawings, capacity chart and mounting data for each O-M Air and Hydraulic Cylinder. MAIL COUPON TODAY for your copies.

Bulletin 101A for Internal Key Tie-Rodless type Air and Hydraulic Cylinders featured above.

Bulletin 105A—Improved Tie-Rod (Heavy Duty) Cylinders Hydraulic 2000 psi; 3000 psi non-shock.

Bulletin 107—Automation (Heavy Duty) Air Cylinder for 200 psi operation.

Bulletin 108—Automation (Heavy Duty) Hydraulic Cylinder—for 1000 psi operation.

ORTMAN-MILLER MACHINE COMPANY
7 143rd Street, Hammond, Indiana

Send Bulletins

☐ Have representative call ☐ 101A ☐ 105A ☐ 107 ☐ 108

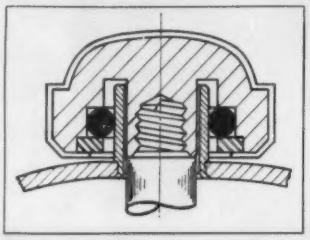
Name_____ Position_____

Company_____

Address_____

City_____ Zone____ State_____

Circle 529 on Page 19



as potentiometers, thermostats, and adjustable timers. Knob seals tubes with ODs from 0.080 to 0.120 in., providing rotating freedom, rotation accuracy, and waterproof protection. It is resistant to vibration, can be used for either rotation or oscillation, and withstands pressures to 35 psi. **Joseph Waldman & Sons**, 133 Coit St., Irvington, N. J.

Circle 759 on Page 19

Trimmer Potentiometer

square unit is rated at 1 w to 70 C

Series 5000 trimmer potentiometer is a 25-turn unit measuring 0.500 x 0.190 x 0.500 in. Sealed to provide protection against moisture and potting compounds, it features welded construction of all fixed connections. Rated at 1 w to 70 C, potentiometer has an operating temperature range of −65 to +150 C. It is available in nine standard resistance values from 100 to 50,-

000 ohms. Standard tolerance is 5 per cent. Unit can be mounted individually or in stacked assemblies. **Dale Electronics Inc.**, Columbus, Nebr.

Circle 760 on Page 19

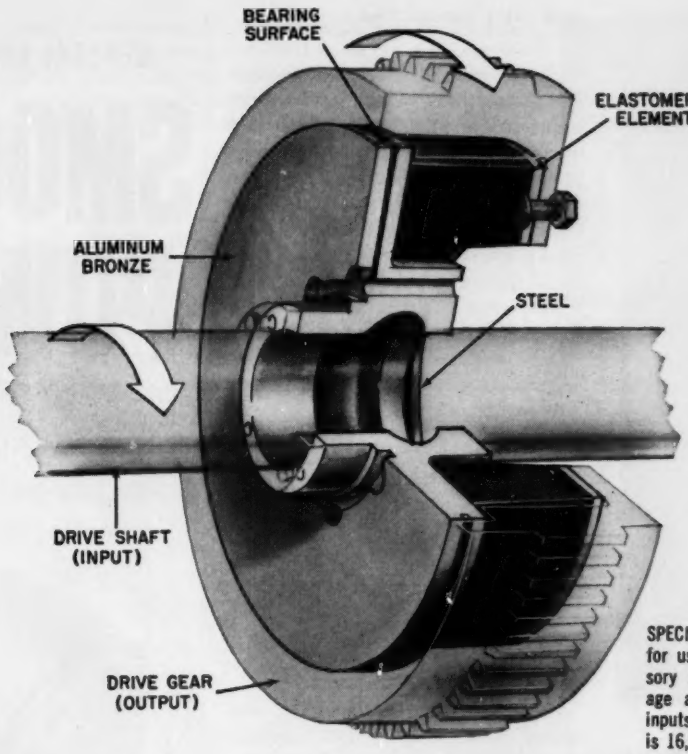
Bar Switch-Light

for palm-of-hand actuation

Multipole, momentary-contact, bar switch-light, Series 34, is a lightweight, molded, panel-mounted bar

Servospeed
HEART OF AUTOMATION
MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL
1/100 — 10 H. P.
Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.
Servospeed
DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave., Paterson, N. J
ARmory 4-8989

Circle 530 on Page 19



SPECIAL COUPLING was designed by Lord for use with gear in diesel engine accessory drive. It protects gears from damage and wear by isolating 8° torsional inputs with 98% efficiency. Torque rating is 16,500 in.-lbs. at 850 rpm.

DESIGN FOR SMOOTH POWER FLOW

with custom-engineered

Lord Flexible Couplings

Torsionally resilient couplings offer important operating advantages for many power transmission applications. Here's what Lord can give you in a special flexible coupling:

Custom design. Couplings can be designed to meet any specific requirements. They can incorporate any degree of flexibility in one or more modes. Elastomers can be specially compounded to resist extreme temperature and oil environments.

Smooth power flow. Lord Couplings provide constant speed transmission of power with no backlash. Torsional disturbances are efficiently isolated. Varying degrees of misalignment—angular, parallel, axial—can be accommodated simultaneously.

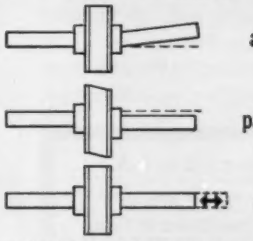
Reliability. Simplified design—no gears, seals, bearings or metal-to-metal contact—assures long service life. Resilience protects driven equipment from damaging inputs and extreme overloads.

Special features. Torque capacities from inch-ounces to foot-tons. Permanently quiet operation. Attenuation of shaft-borne noise. No lubrication or maintenance. Minimum size for given horsepower. Optional fail-safe protection.

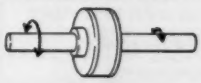
Package assembly. All these features can be incorporated in a special coupling designed by capable, experienced engineers. Your custom couplings will arrive precision produced, fully tested, ready to do your job.

Get more details from your nearest Lord Field Engineering Office or the Home Office, Erie, Pa.

Lord Flexible Couplings accommodate all types of misalignment:



. . . and isolate torsional vibration and shock:



LORD®

FIELD ENGINEERING OFFICES

ATLANTA, GEORGIA · CEdar 7-9247
BOSTON, MASS. · HAncock 6-9135
CHICAGO, ILL. · Michigan 2-6010
DALLAS, TEXAS · Riverside 1-3392
DAYTON, OHIO · BAldwin 4-0351
DETROIT, MICH. · Diamond 1-4340
KANSAS CITY, MO. · WEstport 1-0138
LOS ANGELES, CAL. · HOllywood 4-7593
NEW YORK, N. Y. (Paramus, N. J.)
New York City · BRyant 9-8042
Paramus, N. J. · Diamond 3-5333
PHILADELPHIA, PA. · PEnnypacker 5-3559
SAN FRANCISCO, CAL. · EXbrook 7-6280
WINTER PARK, FLA. · Midway 7-5501

"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY · ERIE, PA.

Circle 531 on Page 19

15 STEPS ELIMINATED

by BRIDGEPORT'S new Cored Forging Method

Originally, a casting requiring heavy cutting, a tube, a web plate and 3 rivets were required. Now a one-piece brass cored forging is polished and plated without machining—and the blanked out web provides the cap.

This stanchion socket benefits from 5 common Cored Forgings advantages.

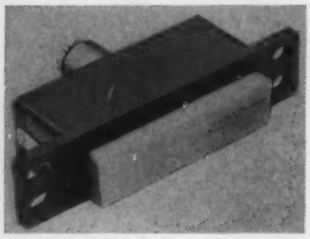
✓	no draft, I.D. or O.D.
	denser, stronger grain
✓	less machining to finish
✓	less assembly required
	thinner walls or sections
	better appearance
	multiple coring
✓	lower cost plating
✓	less scrap/rejects

Which of these process savings or product improvements would apply to *your* part or assembly? Write for descriptive brochure...or send your parts or drawings for our evaluation...to:

CORED FORGINGS DIVISION
BRIDGEPORT BRASS COMPANY
1000 Connecticut Ave., South Norwalk, Conn.

Circle 532 on Page 19

switch intended for palm-of-the-hand actuation. Plunger can be depressed at any point on the lens surface without tilting or binding. Light utilizes standard keyboard switch mechanisms available in a variety of normally open and normally closed contact arrangements. Dual independent lamp circuit provides even distribution of light across the entire surface of the 3 x ¾-in. molded lens. Lens snaps in and is easily removable for rebulbing from the front. It is avail-



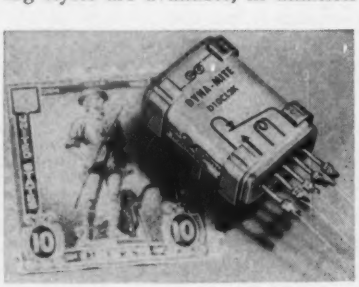
able plain or engraved in red, white, green, and yellow. **Pendar Inc.**, 14744 Arminta St., Van Nuys, Calif.

Circle 761 on Page 19

Precision Relay

tiny unit has 100 mw sensitivity

Dyna-Mite precision relay is 0.2 x 0.4 x 0.6 in. and has a volume of 0.048 cu in. Sensitivity is 100 mw. Weight of the hermetically sealed unit is 0.1 oz maximum. Relay resists vibration of 20g to 2000 cps and shock of 100g. It operates without variation over ambient temperature range of −65 to +125 C at pull-in current of 7 ma maximum for 2000-ohm coil, 18-30 v rating. Relay is a current-sensitive, single-pole, double-throw type. Coil resistances available are 500, 1000, and 2000 ohms, in voltage ranges of 12, 16, and 18-30 v. Two mounting styles are available, in addition

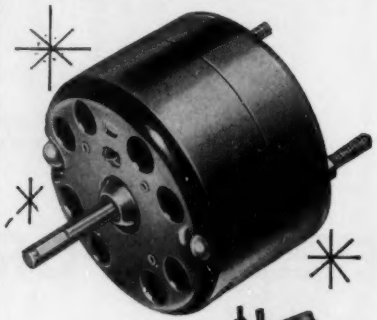


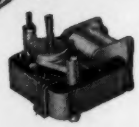
GENERAL INDUSTRIES

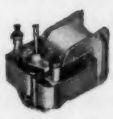
SMOOTH POWER

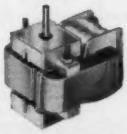
AC MOTORS

pack more power into less space-give dependable trouble-free service!









Standard Line AC Induction Motors from 1/1800 to 1/35 H.P.

In any industry, extra care in manufacturing means an extra margin of dependability. Nowhere else is this "extra" so important as in the manufacture of motors — for a product is only as good as the motor that powers it.

General Industries' complete manufacturing facilities mean economy, too as well as on-time delivery. For any fractional h.p. requirement you'll always be right when you specify G.I.

See Our Catalog in SWEETS 7a-Gen (S) or write for copy

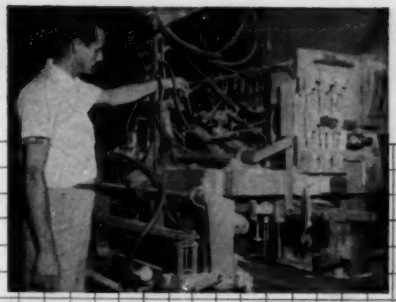
Quantity Price Quotation On Request

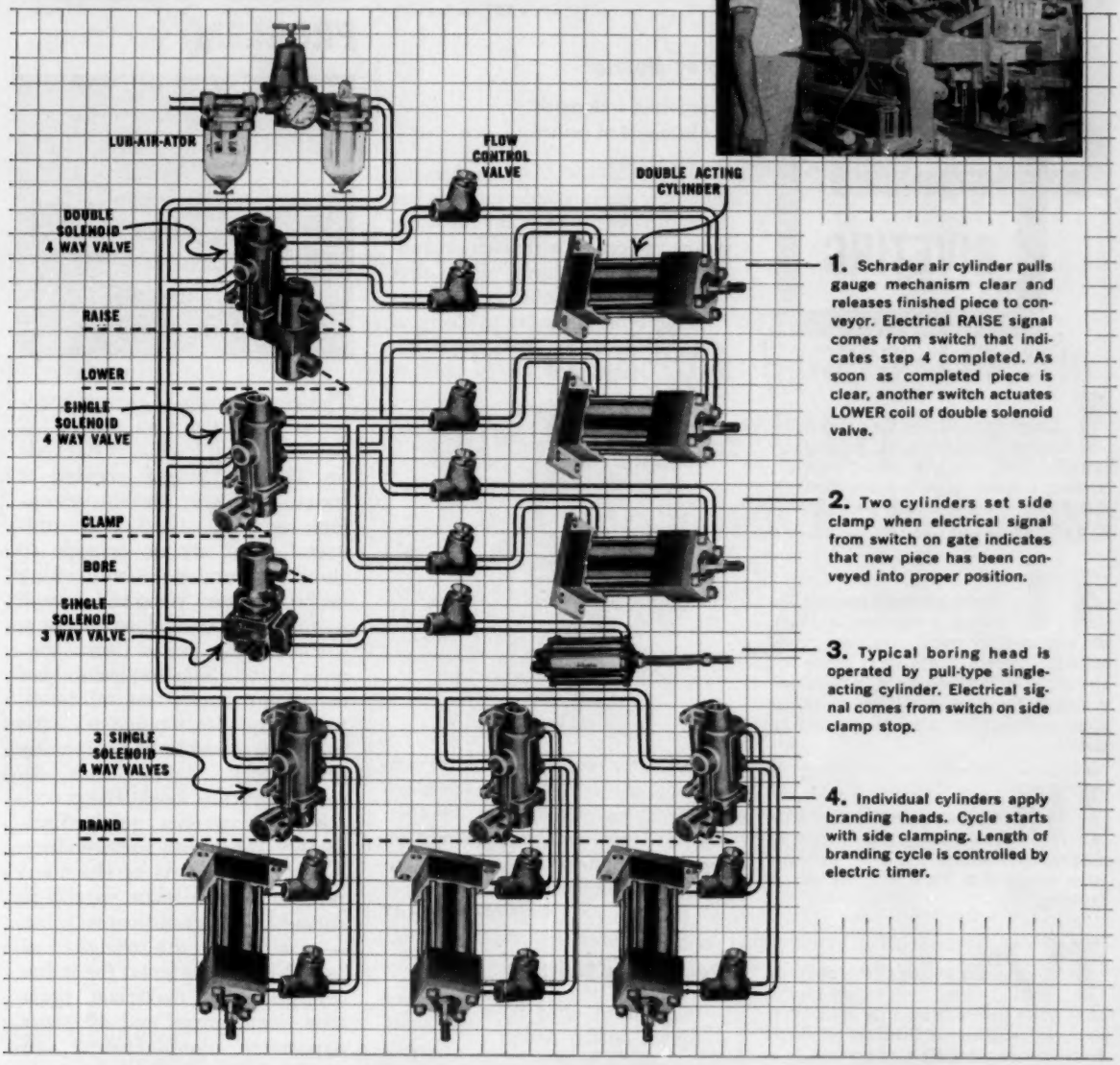
THE GENERAL INDUSTRIES CO.

DEPARTMENT GK • ELYRIA, OHIO

Circle 533 on Page 19

The Lane Furniture Company of Altavista, Virginia, broke its cedar chest production line into groups of operations for air-automation. One of the many circuits, shown here, was designed with quality Schrader components to brand the chest tops with a trademark, bore hinge recesses, and perform vertical and horizontal gang drilling operations. All three jobs are completed in less than 30 seconds!





1. Schrader air cylinder pulls gauge mechanism clear and releases finished piece to conveyor. Electrical RAISE signal comes from switch that indicates step 4 completed. As soon as completed piece is clear, another switch actuates LOWER coil of double solenoid valve.

2. Two cylinders set side clamp when electrical signal from switch on gate indicates that new piece has been conveyed into proper position.

3. Typical boring head is operated by pull-type single-acting cylinder. Electrical signal comes from switch on side clamp stop.

4. Individual cylinders apply branding heads. Cycle starts with side clamping. Length of branding cycle is controlled by electric timer.

MANUFACTURER AUTOMATES PRODUCTION LINE WITH SCHRADER AIR CIRCUITRY... COMPLETES 3 JOBS IN 30 SECONDS

If your plant has production lines too long, unwieldy and costly to compete effectively, take a tip: Break your entire manufacturing sequence into logical *groups* of jobs. Then develop air-powered and air-controlled machines to perform each group in sequence. This company did, and now has versatile, fast, and economical production. *You already have air.* Expand its uses with versatile Schrader Air Products and discover true efficiency.

There is a fully stocked Schrader Distributor nearby . . . staffed with experts to help you solve any air circuitry problem. Consult the Yellow Pages or write:

Schrader®
a division of SCOVILL

A. SCHRADER'S SON
Division of Scovill Manufacturing Company, Incorporated
476 Vanderbilt Avenue, Brooklyn 38, N. Y.

QUALITY AIR CONTROL PRODUCTS

Circle 534 on Page 19

HOW TO SAVE MONEY BY RIVETING

I **Design for rivets.** Use their adaptability not only for assembly, but for electrical contacts, pivots, inserts in molded materials, fastening a number of parts in one operation, joining metallic and nonmetallic parts together, or to each other.

II **Plan on high speed assembly.** Riveting is a high speed operation, and even manually operated machines include automatic hoppers. The uniform quality and strength of Milford semi-tubular, tubular, split or compression rivets permits the use of high speed production equipment by unskilled operators.

III **Count on a positive joint.** A riveted joint can be visually inspected, an advantage not to be overlooked when compared to many other methods of fastening.

IV **Use Milford's "five plant" facilities.** Each Milford plant is strategically located to serve the important industrial areas of the U.S. **Order and get Milford Products when and where you need them.**

Have uninterrupted production with Milford rivet-setting machines. Used singly, or in economical "multiples", where you set more than one rivet with no increase in labor or handling costs, Milford riveters, setting Milford rivets, are the surest way to lowest in-place assembly cost.

THE MILFORD RIVET **MILFORD RIVET & MACHINE CO.**

MILFORD, CONNECTICUT • HATBORO, PENNA.
ELYRIA, OHIO • AURORA, ILL. • NORWALK, CALIF.

Circle 535 on Page 19

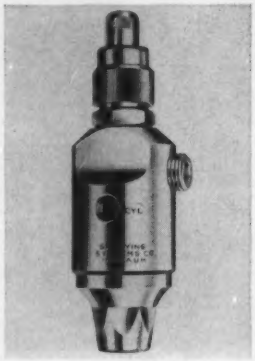
to the hermetically sealed enclosure. Control Dynamics Corp., 7420 Fulton, North Hollywood, Calif.

Circle 762 on Page 19

Spray Nozzle

provides automatic clean-out of orifice

Model 8651-1/4JAUH automatic hydraulic spray nozzle incorporates clean-out needle that automatically cleans the orifice with each on-and-off cycle of the nozzle. Each time valve closes, clean-out needle moves through orifice opening to clear out any solid residue that might adhere. Compressed air is used to



actuate the valve. Precision air-cylinder-actuating mechanism is operated at any speed up to 180 cpm. Orifice tips are interchangeable. Spraying Systems Co., 3274 Randolph St., Bellwood, Ill.

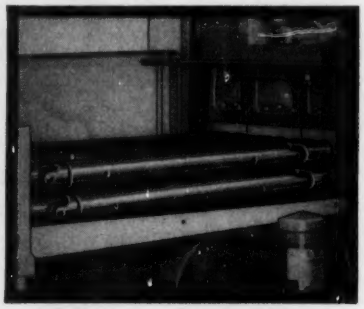
Circle 763 on Page 19

Pushbutton Switches

illuminated units have square button design

New illuminated push-push switches include two lines: Series 15000, illuminated, nonlock units that can be converted to push-to-lock, push-to-release function; Series 15000L, illuminated pushbutton switches with push-to-lock, push-to-release function, convertible to momentary action. Switches feature a square button design which provides side and front illumination and a large area for engraving identification. Buttons are keyed in any of four planes for vertical or horizontal switch frame mounting. Three lamp voltages available are 6 v, 28 v, and neon (115 v ac). Each

HOW CURTIS SOLVED A CLOSE CENTER-TO-CENTER PROBLEM

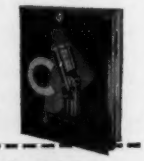


The close center-to-center spacing of these drive spindles on a Sutton-Maust Precision Backed-up Roller Leveler created a tough problem for its manufacturer. He needed a universal joint strong enough to stand up under heavy rolling mill conditions, yet small enough to operate at such close quarters.

The answer was a Curtis universal joint! The maximum load carrying capacity and minimum torsional deflection of the Curtis joint was found to be completely satisfactory. And Curtis' famous Telltale Lock Ring construction permits quick disassembly for easier maintenance.

This is just one of the many power transmission problems solved by Curtis universal joints — size for size the *strongest* universal joints designed for industry. Selected materials, precision engineering, and 40 years' experience manufacturing universal joints exclusively make them that way.

WRITE FOR THE NEW CURTIS CATALOG, JUST PUBLISHED



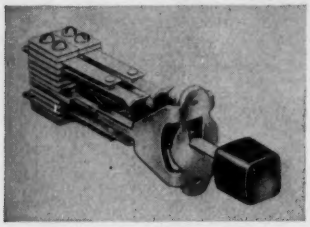
14 sizes always in stock 3/8" to 4" O.D.

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK **CURTIS**

UNIVERSAL JOINT CO., INC.
53 Birnie Ave., Springfield, Mass.
As near to you as your telephone

Circle 536 on Page 19



switch frame has two tapped screw holes for convenience of panel mounting. Switches can be mounted on 5/8-in. centers. **Switchcraft Inc.**, 5555 N. Elston Ave., Chicago 30, Ill.

Circle 764 on Page 19

Polycarbonate Resin

has high luminous transmittance values

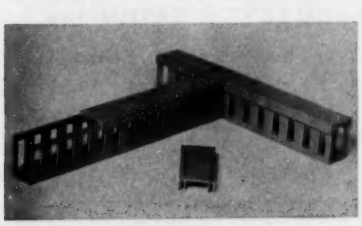
Color stabilized Lexan 101 polycarbonate resin has excellent physical, electrical, and chemical properties of earlier grade, but exhibits luminous transmittance values 5 to 10 per cent higher because darkening during processing and molding is prevented by color-stability additive. Applications for the new material include electrical and electronic housings, aircraft instruments, light diffusers, and other components where transparency and translucency are important. Color stability permits more widespread use of regrind material, and simplifies the production and matching of colors. **Chemical Materials Dept., General Electric Co.**, Pittsfield, Mass.

Circle 765 on Page 19

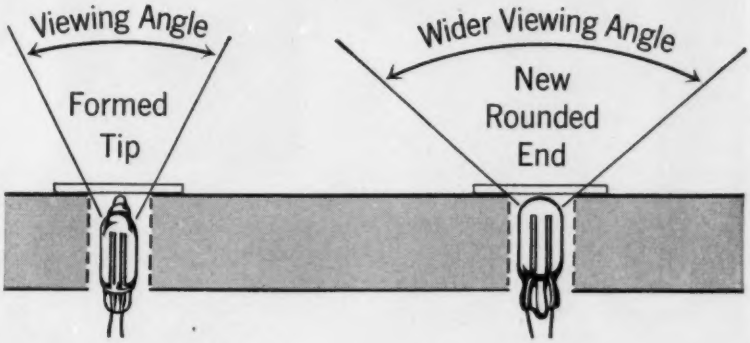
Panel-Wireway System

of high-impact, rigid-vinyl plastic

"Ball-and-socket" feature in new 1-in. panel-wireway system permits quick application or removal of cover. Cover has a socket that is molded into each of its sides. Each socket snaps firmly into a respec-



New round end General Electric glow lamps for better viewing . . . and better looking indicators!



New shape of the Round End Glow Lamp brings its electrodes nearer to the end of the bulb—giving it a much wider viewing angle when flush mounted (see illustration above). And if the Round End Glow Lamp is placed beneath translucent material, the lighted area has a more uniform appearance.

The rounded end of clear-glass gives a distortion-free light when viewed end-on from any angle. Because of its smooth round end, this lamp can be used as a protruding element, thus improving the appearance of the panel.

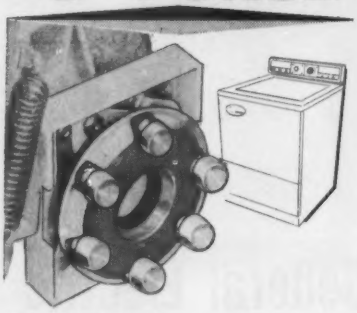
New General Electric NE-2M (for standard brightness) and NE-2P (for high brightness) Glow Lamps are more thoroughly described in the engineering data sheet, #3-9289. For your free copy, write: General Electric Company, Miniature Lamp Department M-112, Nela Park, Cleveland 12, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 537 on Page 19

SYNPRO-TEX
Speed Detectors Control
"G" FORCE



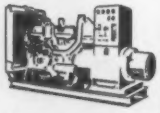
Pats. & Pats. Pend.

In one of the many and varied applications of TORQ speed detecting devices, a single SYNPRO-TEX speed detecting governor is used in a washer-drier appliance to . . . (1) reduce vibration by balancing clothes load. (2) Provide more thoroughly dried clothes. (3) Reduce wrinkling. The SYNPRO-TEX governor automatically cuts out the motor above 1G, switches it back on below 1G for approximately 20 cycles.

SYNPRO-TEX governors are "frictionless", snap-acting, centrifugal switches . . . actuated by speed only, accurate to 0.25% at speeds from 0 to more than 15,000 rpm, for over 1,500,000 cycles of uniform operation. TORQ governors can detect speeds dependably and economically on anything from rotating rat-traps to guided missiles. What's your problem?

MISSILES
Control of rotational speed for ballistic accuracy. Protection and control of components. Ask for Bull. 260.

GAS BURNERS
Fuel control for safety in starting and operation. Blower protection. Ask for Bull. 265.



GAS ENGINE GENERATOR SETS
Automatic switching of cranking cycle. Overspeed protection. Ask for Bull. 264.

These uses illustrate a few of the many ways to increase operating reliability or reduce costs with TORQ speed detecting control.

THE WORLD'S LARGEST MANUFACTURER OF SPEED DETECTORS

TORQ
ENGINEERED PRODUCTS, INC.
26 West Monroe Street Bedford, Ohio
Phone: BEdford 2-4100

Circle 538 on Page 19

tive ball on each panel wireway side. Cover stays on even when overloaded. High-impact, rigid, vinyl-plastic material is nonflammable and withstands temperatures to 165 F. **ECP Corp.**, 4726 Superior Ave., Cleveland 3, Ohio.

Circle 766 on Page 19

Laminated Solenoids

are available in three sizes

Super-T redesigned solenoids are laminated units available with moisture-resistant, moistureproofed coils, or with coils completely encapsulated in epoxy resin. Three

sizes are available for use in business and commercial machines, automation equipment, vending machines, and small machine tools. **Dormeyer Industries**, Dept. MD-1, 3418 N. Milwaukee Ave., Chicago 41, Ill.

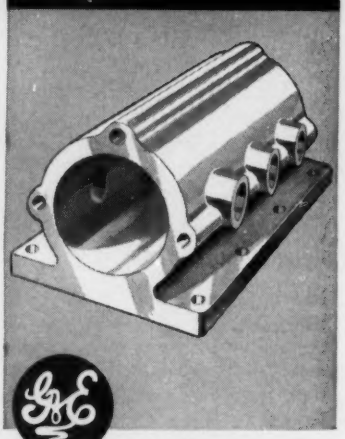
Circle 767 on Page 19

Pinpoint Lens-Holder

adapts photoelectric scanner to tiny parts and movements

Lens-holder and tunnel aperture can be used on either light-source or the photocell of miniature photoelectric scanner. When used on photocell, unit provides a narrow field of vision that enables the scanner to detect small objects over distances to 10 ft and movement as low as 0.001 in. for slow-moving objects near the photocell. It also minimizes the effect of ambient light. When used on the light-source, unit produces a small, sharply defined round spot of light which enables the scanner to detect objects only 0.010 in. diam or

FROM DESIGN TO PRODUCTION LINE QUICKLY WITH



ALUMINUM and GREY IRON CASTINGS

Your design becomes a practical reality with superior castings from Gillett & Eaton, nationally known piston manufacturers. High alloy grey iron castings, aluminum and hypereutectic alloys in sand, semi-permanent or permanent mold. Complete pattern shop, tool room, x-ray and heat treating facilities, modern laboratory and piston machining facilities. Quality castings to your specifications—at a competitive price. Write for our quote.

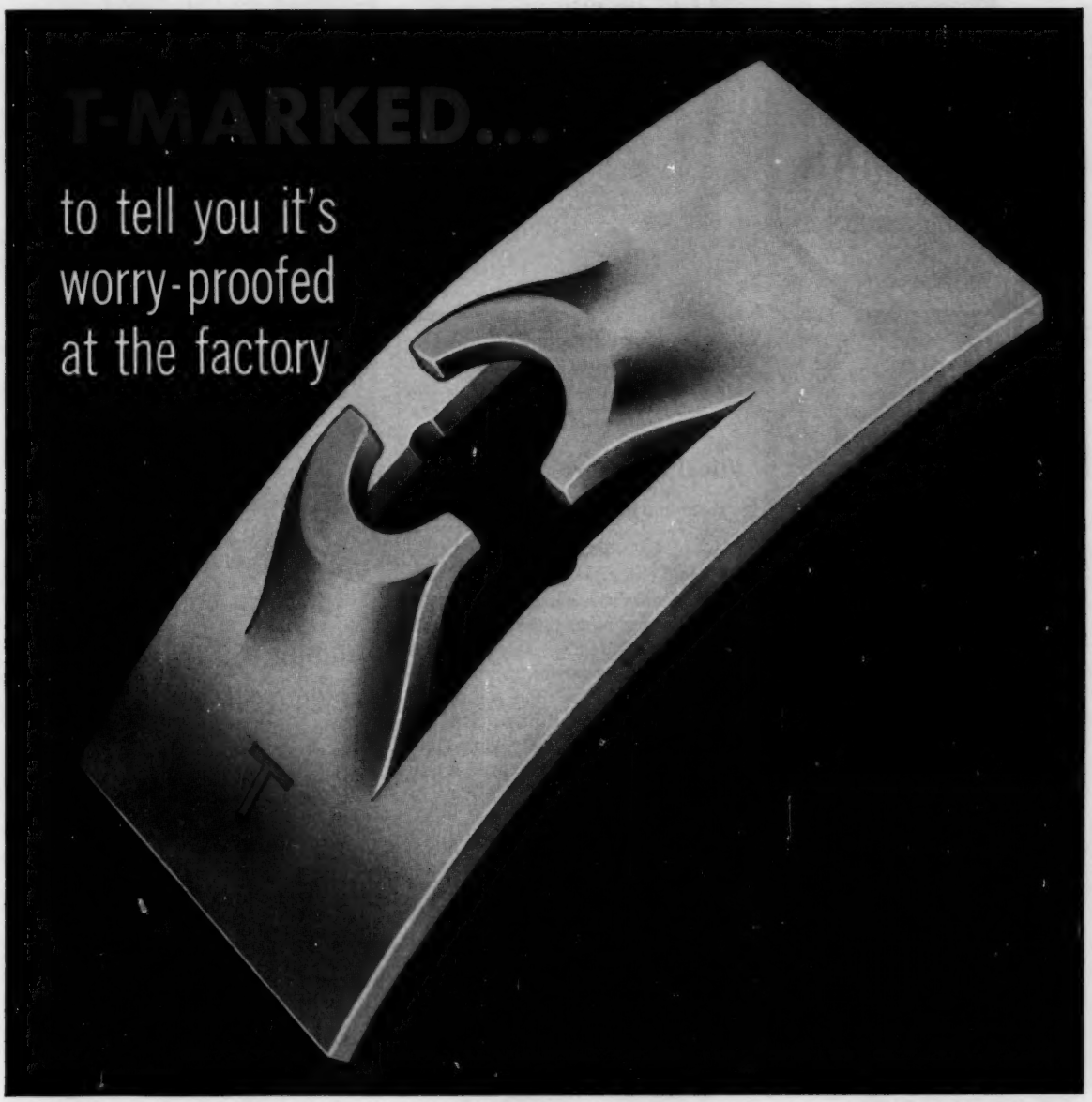
GILLETT & EATON, Inc.
860 Doughty Street, Lake City, Minn.

Sold in Canada by
Gould National Batteries of Canada, Ltd.
Fort Erie, Ontario

Piston and casting specialists

Established 1868

Circle 539 on Page 19



Other spring fasteners may look like Tinnerman SPEED NUTS. But only the *T-marked* ones really are SPEED NUTS . . . really are "Tinnermans". . . made to highest quality and precision standards to assure worry-proof performance on your assembly.

Here's what the exclusive Tinnerman T-mark means to fastener users:

Over thirty-five years of Tinnerman experience as the originator and largest producer of spring-steel fasteners...the leader in solving your fastening problems,

Outstanding fastener design and production experience that assures you the best possible design of SPEED NUT, whether it is a special SPEED NUT or one of the 10,000 SPEED NUT brand fasteners presently available,

Stringent control of SPEED NUT quality from coil strip to you, including die design, production, heat treatment and finishing.

Be sure you specify "Tinnerman T-marked SPEED NUTS" that give you better fastening, that cut parts and assembly costs, that never let you or your customer down. *Tinnerman Products, Inc., Dept. 12, Box 6688, Cleveland 1, Ohio.*

TINNERMAN
Speed Nuts®
Look for the Tinnerman "T"

Circle 540 on Page 19

WATERMAN

Series 190

FLOW REGULATORS

Constant Speed Operation

regardless of load!

At a cost comparable to an ordinary restrictor or needle valve, you can have pressure-compensated flow control in your hydraulic circuits.

Rated for pressures to 3000 p.s.i.

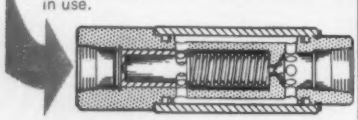
Wide range of sizes available—¼" to 1½" N.P.T.F. and ¼" to 1" S.A.E. tube.

Flows to 100 g.p.m. can be controlled.

Factory-calibrated and tested to ±10% tolerance. Closer tolerance available.

Require little more space than pipe or tube in which installed.

Trouble-free in operation—tens of thousands in use.



Unit senses pressure drop across precise orifice and reacts to control flow with desired limits.

Send today for new Catalog 1002.

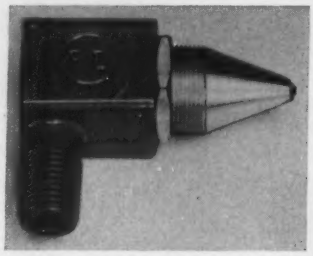
MEMBER NFPA

W-6108

WATERMAN HYDRAULICS CORPORATION

725 Custer Ave., Evanston, Ill.

Circle 541 on Page 19



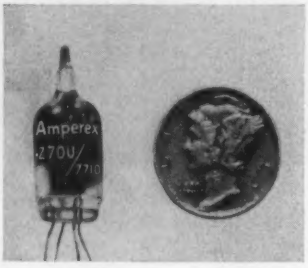
to follow lines in a tracing operation. **Farmer Electric Products Co. Inc.**, 2300 Washington St., Newton Lower Falls, Mass.

Circle 768 on Page 19

Visual Indicators

need no heating power

Line of gas-filled visual indicators and cold-cathode trigger tubes (including numerical-display types) is available for applications in computers and industry. Trigger tubes need no heating power, therefore require no warm-up time for operation. Inoperative during stand-by periods, they have very long life. Included in the line are many unique types, such as Type Z7OU/7710 subminiature trigger tube, suited for printed-circuit applications, numerical-display tubes designed for transistorized circuits, and selector and counter tubes that do



not require interstage amplifiers. **Semiconductor & Special Purpose Tube Div., Amperex Electronic Corp.**, 230 Duffy Ave., Hicksville, L. I., N. Y.

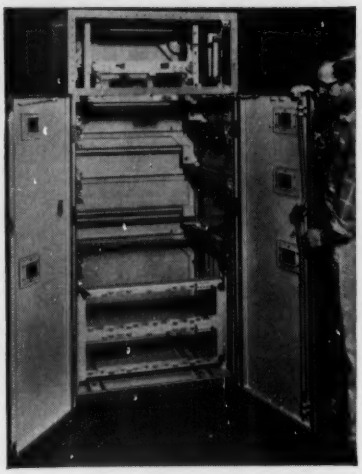
Circle 769 on Page 19

Copper-Clad Laminate

for microwave printed circuitry

Tellon 3A copper-clad laminate is a completely isotropic material with a low dielectric constant of 2.36 ±0.01 and a dissipation factor of

Example . . .



. . . of B & P capability to make lightweight metal assemblies for electronic equipment

Designing and manufacturing products and assemblies of light metals is a highly specialized field. Techniques unknown to production in other metals must be understood and new ones must be developed for unusual requirements.

Because it has concentrated on light metal manufacturing for many years, Brooks and Perkins today has experience and capability unmatched by any other organization.

The Nike-Hercules system magnesium cabinet shown above is just one example of B & P skill in maintaining close tolerances and optimum precision. Other products and assemblies designed and produced by B & P include . . .

• cooler plates • radar reflectors • communication equipment covers • radar reflector bases • equipment housings • tripods • radar plotting equipment • shelters • transit cases • gun fire control housings and turrets

When you need lightweight products or assemblies for electronic equipment, take advantage of B & P's experience and capability.

BROOKS & PERKINS, INC.

1940 W. Fort St., Detroit 16, Mich.

Offices in Washington and New York

61-T-2

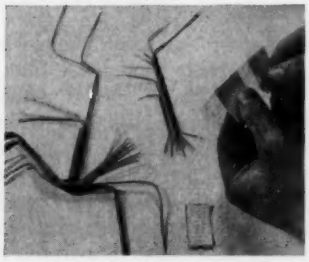
Circle 542 on Page 19

0.0002. Intended primarily for microwave and UHF printed circuitry, it exhibits excellent moisture and chemical resistance. Minimum peel strength is 5 lb-in., and nominal strength is 15-20 lb-in. Material can be cold punched, drilled, and machined as required. Eyelets can be set either flush or below the surface without danger of cracking the laminate. It can be soldered by conventional techniques, including roller-coating. Operating temperatures are 250 F continuous and 500 F intermittent. Laminate is available in sheets to 14 x 18 in. with thicknesses from 0.020 to 0.125 in. It can be clad in any weight copper, both sides; standard is 2-oz copper. **Military Electronics Div., Tell Mfg. Co.**, 520 Cary St., Orange, N. J.

Circle 770 on Page 19

Custom Harnesses

for high-temperature use



Custom-made harnesses are manufactured from Teflon TFE-insulated Multi-Tet ribbon cable. Abrasion and corona-resistant cables are also available. Harnesses can be used at high temperatures and in corrosive environments. Any combination of wire sizes, conductors and color-coding is possible. **W. L. Gore & Associates Inc.**, 555 Paper Mill Rd., Newark, Del.

Circle 771 on Page 19

Retaining Spring Clips

for socket-mounted transistors

Two retaining clips for socket-mounted TO-5 and TO-9 series transistors comply with military requirements for retention of plug-in devices. Designated 3B-714-1 and 3B-714-2, clips provide positive spring-pressure retention on transistor case top and easy access for service. Transistor socket mounts

SPECIFY ZEUS
CUSTOM-ENGINEERED
ELECTRIC MOTORS

engineering Pesco production

PESCO B-W PRODUCTS
BORG-WARNER

TO MEET YOUR SPECIFIC OPERATING AND PACKAGE REQUIREMENTS

✓ MINIMUM ENVELOPE SIZE

Extremely tight windings, low air-gaps, compact brush riggings, recessed armature end turns . . . keep Pesco motor sizes to a minimum.

✓ DYNAMICALLY BALANCED COMPONENTS

All rotating components . . . fans, rotors, shafts . . . are dynamically balanced—individually, and as complete assemblies.

✓ EXCLUSIVE COOLING ACTION

Pesco axial flow fan rotors provide exceptional aerodynamic cooling . . . assure extended motor life and efficient operation at elevated temperatures.

✓ COORDINATED FRAME DESIGN

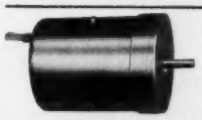
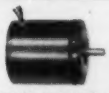
Standard coordinated frame sizes . . . custom-adapted to specific power requirements . . . give high horsepower-to-weight ratios. Basic motor diameters range upward from 1.25 inches.

✓ LIGHTWEIGHT PACKAGE

Cast aluminum end bells and bases, hollow shafts on specified models, high operating speeds . . . these features contribute to more horsepower per pound in Pesco motors.

✓ MIL SPEC DESIGN

Pesco electric motors . . . AC, DC, or miniaturized series . . . are built to the exacting standards of Mil-M-7969 and Mil-M-8609. When ordered, any Pesco motor will be qualified to these specifications.

	Horsepower Range	Motor OD	Weight
 AC MOTORS	.018 to 20	2.2 to 8.25"	.8 to 90 lbs.
DC MOTORS	.005 to 5 (cont) .3 to 15 (int)	1.75 to 4.75"	1.3 to 21.5 lbs.
 MINIATURIZED AC AND DC MOTORS	.003 to .09	1.25 to 1.68"	4.8 to 12 oz.

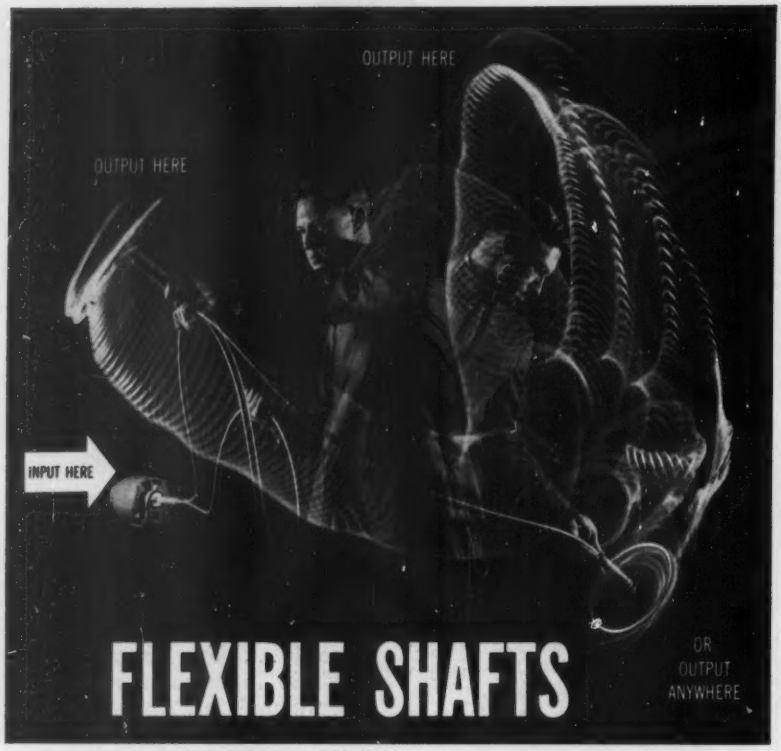
PESCO PRODUCTS DIVISION
BORG-WARNER CORPORATION
Dept. D-3 24700 N. Miles Rd.
Bedford, Ohio

Please send me complete information about Pesco Electric Motors.

Name_____
Company_____
Street_____
City_____ Zone____ State_____

10294-PC

Circle 543 on Page 19



put power where you want it

Flexible shafts give the designer important new freedom in transmitting rotary power or control between two points. They enable you to position your power source and your driven part to best advantage . . . without worrying about obstructions, vibration, shock or alignment.

Even if the components are in relative motion to each other, you can still transmit power smoothly and economically.

Flexible shafts also reduce manufacturing costs . . . use fewer parts . . . eliminate cumbersome gears, drives, couplings, universals. With rigid connections gone, alignment and tolerance problems fade away, and installation is a snap.

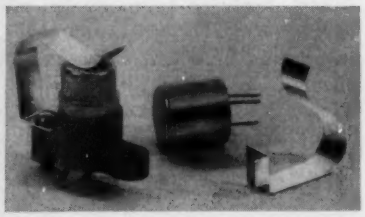
Whatever your rotary transmission problem, there is a good chance that one of S. S. White's flexible shaft lines can solve it . . . *Standard, Pre-Engineered,* or *Custom-Designed* flexible shafts.

S. S. WHITE INDUSTRIAL DIVISION,
DEPT. 4, 10 East 40th Street, N. Y. 17, N. Y.

THE S. S. WHITE FLEXIBLE SHAFT HANDBOOK
New 4th Edition . . . Send for your free copy!

1158

S.S.White
FIRST NAME
IN FLEXIBLE SHAFTS



to chassis by screw or rivet. Locking tab on the clip positions it and prevents twisting. Two heights are available for transistors with mounting-height dimensions of 13/64 and 21/64 in. Material is beryllium copper per QQ-C-533 with a silver-plate finish. **Industrial Div., Birtcher Corp.,** 745 S. Monterey Pass Rd., Monterey Park, Calif.

Circle 772 on Page 19

Miniature Motor

is governed to tolerance of ±½ per cent

New 1¼-in. P.M. or reversible series motor combines motor, gear train, governor, and noise filter in a single package. Unit provides a life expectancy of 1000 hr without maintenance, and can be governed within ±½ per cent. Motor meets MIL-M-8609 (ASG) requirements for vibration, salt spray, fungus, humidity, and other environmental conditions, and operates over an ambient temperature range of −65

to +200 F. It produces 1/75 hp from an input voltage of 22-31 v dc. Maximum current is 0.85 amp, and speed is 18,500 rpm at 26 v dc. **Electro-Actuators Div., Omega Precision Inc.,** 757 North Coney Ave., Azusa, Calif.

Circle 773 on Page 19

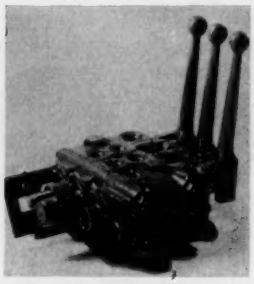
Multiple-Unit Valves

for use on mobile equipment

CM11 series multiple-unit valves are designed for use on multiple-

Circle 544 on Page 19

operation mobile machinery such as materials-handling and construction equipment. They are available in any number of sections up to ten, with individual load checks in each section, and are rated for operation to 2500 psi. Valves are nominally rated at 15 gpm; higher flow rates are possible with pressure drops acceptable to the user. Other features include improved metering, reduced leakage from cylinder



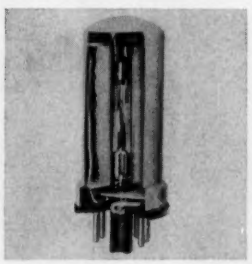
to tank, improved detents, and compact size. **Vickers Inc., Div., Sperry Rand Corp.**, Detroit 32, Mich.

Circle 774 on Page 19

Mercury-Wetted Contact Relay

has minimum operate time of 3 millisec with 2-w coil input

Series V51 mercury-wetted contact relay is adaptable to computers, data-processing equipment, and machine-tool applications. High-speed relay is capable of high-power or low-level operation. Relay consists of a contact assembly mounted and sealed in a glass capsule, an operating coil, and a steel housing with an eight-pin octal plug. Switch capsule is enclosed by the coil, is thus located in the magnetic field set up by the coil. Minimum operate time of the single-capsule relay is 3 millisec with a coil input of approximately 2 w. Release time is about 3 to 3½ millisec under all conditions of coil input power. Switch capsule can be driven at



FOR MOBILE EQUIPMENT
FOR MATERIALS HANDLING SYSTEMS
FOR MISSILES, ROCKET LAUNCHERS AND AIRCRAFT
FOR METALWORKING MACHINERY AND TRANSFER EQUIPMENT
FOR FARM EQUIPMENT
FOR PRINTING, PAPER PROCESSING, WOODWORKING AND OTHER SPECIAL INDUSTRY MACHINES
FOR RAILROAD EQUIPMENT
RACINE
HYDRAULIC COMPONENTS
The heart of BETTER MACHINERY
Racine hydraulic pumps, valves, controls and pressure boosters are available for application in practically every hydraulically operated circuit . . . be it in use or in the design stage . . . whether on equipment being manufactured or equipment used in manufacturing. For the most versatile, the most stout-hearted hydraulic components, RACINE is a popular choice with industry everywhere.
RACINE
Racine Hydraulics & Machinery, Inc.
RACINE, WISCONSIN
HYDRAULICS DIVISION

Circle 545 on Page 19

TRANSFER MACHINE BUILT BY BUHR MACHINE TOOL CO., ANN ARBOR, MICHIGAN

Automated GIANTS like this

REQUIRE STRONG HYDRAULIC *HEARTS* EVERY MINUTE OF THEIR WORKING LIFE

24 RACINE PUMPS *operate this 58 station 500-ton transfer machine*

The precisioned flow control of RACINE PUMPS assures the split-second timing and efficiency required to operate this complex Buhr Transfer Machine . . . custom-built for the completely automatic machining of 120 auto-cylinder heads hourly for a leading automotive manufacturer. Compact RACINE VALVES control feeds and reverse movements on all 323 operations performed by the machine. RACINE 4-WAY SOLENOIDS help one man operate this mechanical giant. Buhr has used RACINE PUMPS and Reservoir Units on custom-built machines for the automotive industry for over 10 years.

RACINE

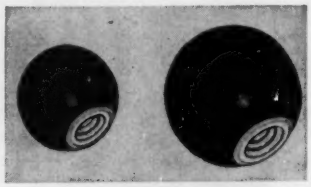
Racine Hydraulics & Machinery, Inc.
RACINE, WISCONSIN
HYDRAULICS DIVISION

speeds to 100 operations per sec. Relay switches 250 v-amp loads with maximum of 5 amp, 500 v. It has an operating sensitivity of 250 mw, minimum. Relay has 1.105 in. diam and is 3.196 in. high. **Automatic Electric Co.**, Northlake, Ill.

Circle 775 on Page 19

Ball Knobs

are available in several sizes



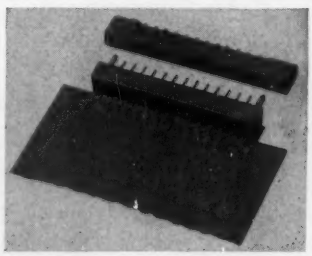
Plastic ball knobs with diameters of $\frac{3}{4}$, 1, $1\frac{3}{8}$, and $1\frac{7}{8}$ in. have tapped brass inserts. One thread size is available in the smallest diameter. Four thread sizes are furnished in the 1-in. diam, four sizes in the $1\frac{3}{8}$-in. diam, and three sizes in the $1\frac{7}{8}$-in. diam. **Northwestern Tools Inc.**, 117 Hollier Ave., Dayton 3, Ohio.

Circle 776 on Page 19

Printed-Circuit Connectors

in 4 to 38-contact units

Expanded group of right-angle, printed-circuit connectors in several series is available in a variety of molding compounds. The plug-and-socket connectors are furnished in contact sizes from 4 to 38. All dip-solder to a printed circuit board at right angle to the plug and receptacle contacts. Terminations include solder cups, turret terminals, wire-hole solder lugs, or taper-pin terminations for solderless wiring. Pin contacts are brass and stainless steel, gold plate over silver plate. Socket contacts are phos-



Circle 546 on Page 19

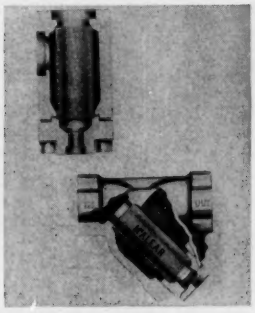
phor bronze with gold plate over silver plate. **Electronics Div., De-Jur-Amsco Corp.**, 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 777 on Page 19

Angle and Y-Strainers

revised line is for heavy-duty use

Revised and expanded line of Y-strainers and a block-steel angle strainer are now available. No. 530 and 530-G Y-strainers are suitable for all steam, water, air, oil, or gas applications. They protect traps, regulators, meters, and other equipment from foreign material. Following materials and sizes are available: Semisteel, ¼ through 3 in.; ductile iron or cast steel, ⅜ through 2 in.; bronze or stainless steel, 1½ through 2 in. Stainless screens are standard for all strainers. No. 532 block-steel angle strainer is designed for service to 1500 psig at



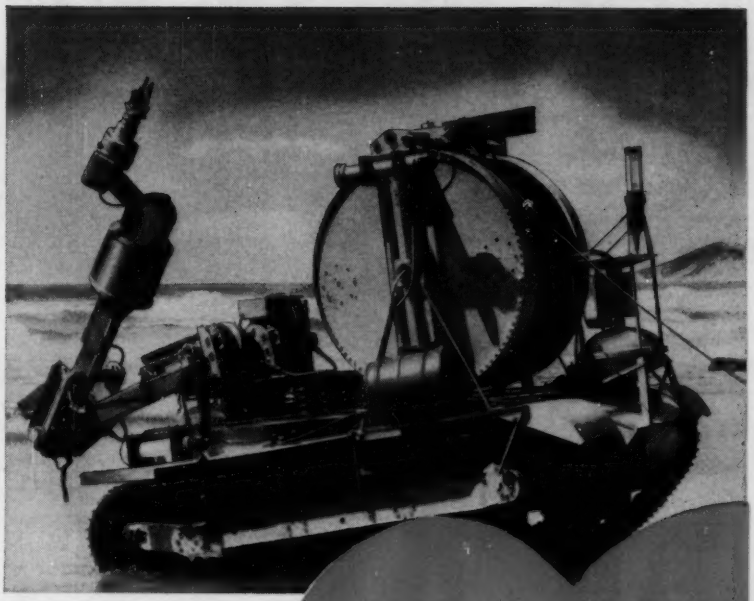
850 F, cold pressures to 3500 psi, water, oil, or gas, in carbon steel, and higher pressure-temperature applications with chrome-moly steel series. They are available in connecting pipe sizes ½ to 3 in. **McAlear Mfg. Co.**, 1901 S. Western Ave., Chicago 8, Ill.

Circle 778 on Page 19

Miniature Thermostat

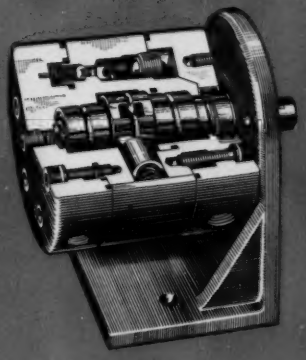
for operating temperatures to 300 F

Miniature immersion alarm thermostat, Model 265, is suited for use in liquid-cooled engines and oil-cooled transformers. Unit does not impede the flow of circulating liquids, can be used in conjunction with alarm devices, pilot lights, solenoids, and relays. Contacts are normally open,



REMOTE UNDERWATER MANIPULATOR BUILT FOR THE U. S. NAVY BY THE SCRIPPS INSTITUTION OF OCEANOGRAPHY OF THE UNIVERSITY OF CALIFORNIA AND THE HUDSON LABORATORIES OF COLUMBIA UNIVERSITY.

This hardy HYDRAULIC HEART operates efficiently even 20,000 ft. under water



The Heart of this Exotic Ocean Explorer Is a RACINE MODEL D6 PUMP

A RACINE pump actuates the mechanical arm on the Remote Underwater Manipulator, a new experimental vehicle the U. S. Navy uses to explore the ocean floor down to depths of 20,000 ft. The arm makes all the motions of the human arm and hand. It picks up samples from the ocean floor . . . assembles and installs instruments in the ocean depth. Land-based remote controls operate the underwater explorer. Rated at 1,000 psi continuous pressure, the RACINE pump automatically compensates for the compressibility of oil under various sea water pressures. When you need *versatile* hydraulic components — sturdy and dependable for *any* use from research to assembly line — your best choice is RACINE!

RACINE

Racine Hydraulics & Machinery, Inc.
RACINE, WISCONSIN
HYDRAULICS DIVISION

Circle 547 on Page 19

NEW NYLAFLOW® PRESSURE HOSE

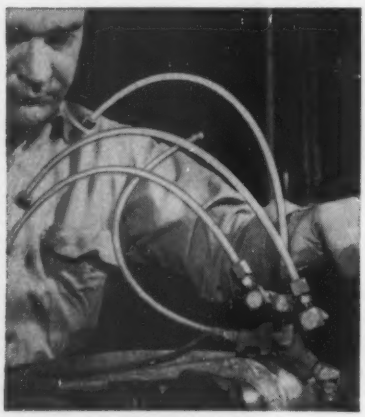
Weighs 1/5 as much...outperforms rubber hose of same burst strength

Flexible NYLAFLOW Pressure Hose* is Polymer's newest answer to jobs requiring exceptional resistance to flex and vibrational fatigue.

Available in burst pressure ratings of 5000 and 8000 psi., and in long, continuous lengths and standard inside diameters up to ½" . . . with compact, lightweight, reusable fittings or assemblies if desired.

Unaffected by flammable and non-flammable hydraulic fluids, hydrazine and other rocket fuels, with excellent resistance to hot paint and almost all organic solvents. Freon permeability is approximately 1/10 that of rubber hose. An excellent non-conductor.

Odorless, non-toxic, non-corrosive, fungus resistant and will not embrittle in storage. Temperature range (−65°F. to +225°F.). Flexible but can be permanently heat-formed to small, stress-free bend radii.



NYLAFLOW PRESSURE TUBING in sizes up to ⅜" O.D., and burst pressure ratings of 1000 and 2500 psi. Ideal for lower pressure requirements. Flexible for easy installation with standard flare or compression fittings.

Full details and illustrated brochures now available

WRITE TODAY!

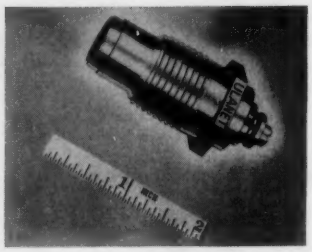
POLYPENCO

INDUSTRIAL PLASTICS

THE POLYMER CORPORATION of PENNSYLVANIA, READING, PA.

EXPORT POLYPENCO, INC., READING, PA., U.S.A.

*Patents applied for



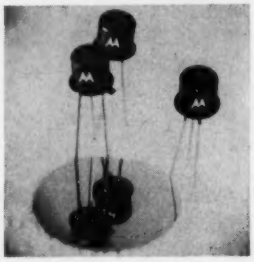
closing with rise in temperature. The ½-in. pipe-threaded body serves as a grounding terminal, and over-all dimensions are 2 x ⅞ in. Units are preset to customer specifications, and are available for operating temperatures to 300 F. **George Ulanet Co.**, 413 Market St., Newark 5, N. J.

Circle 779 on Page 19

Epitaxial Mesa Transistors

for high-frequency uses

Silicon and germanium epitaxial mesa transistors are available in both switch and amplifier types. Electrically equivalent to micro-alloy types, they retain the high power capability and high reliability normally associated with mesa-



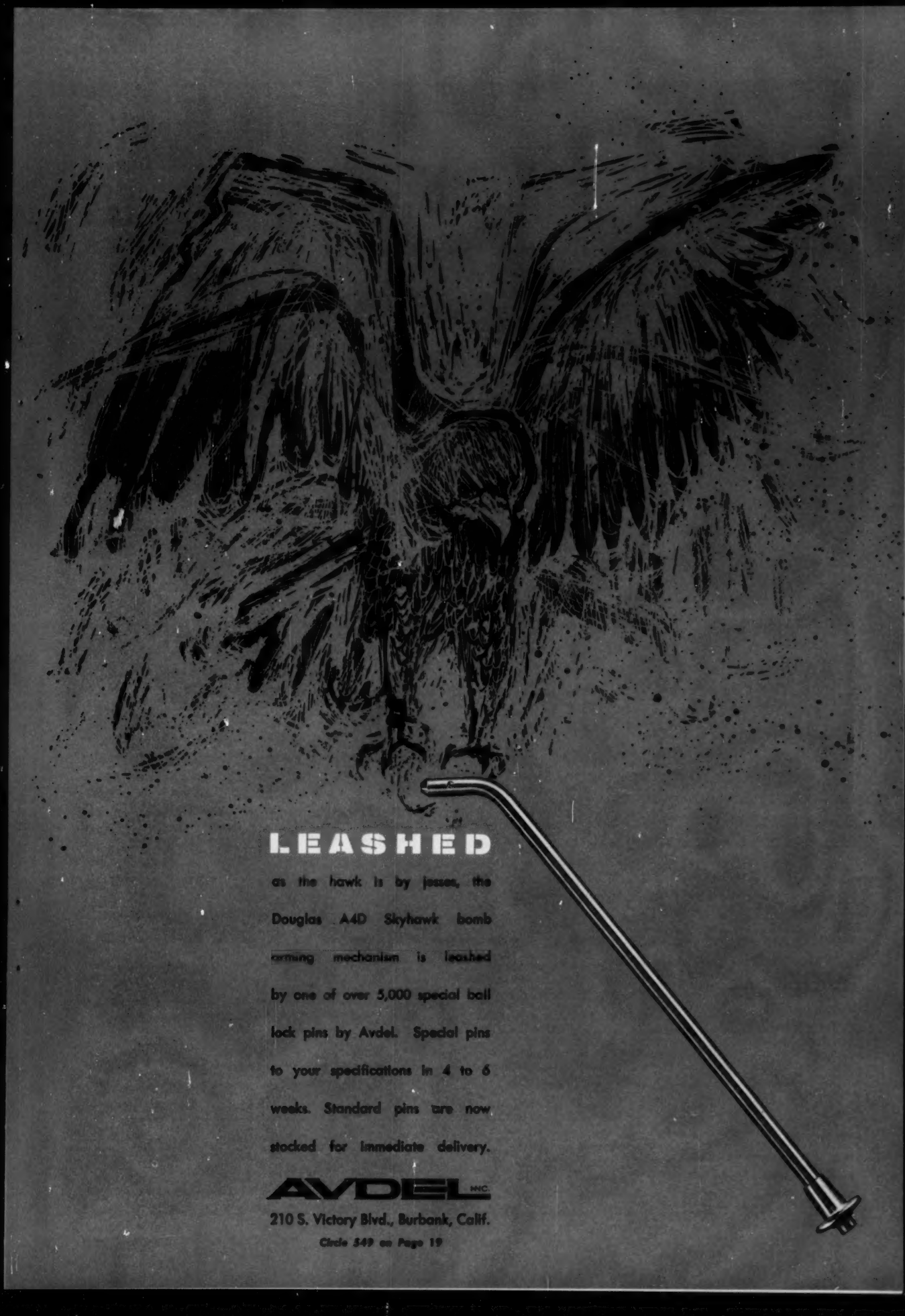
type transistors. **Motorola Semiconductor Products Inc.**, 5005 E. McDowell Rd., Phoenix, Ariz.

Circle 780 on Page 19

Swivel-Lock Caster

in one, two, three, or four-position lock units

Improved swivel-lock caster mechanism is now available, on practically all swivel-caster models. Mechanism utilizes spring-loaded-pin stop principle, but in addition includes a specially formed structural nylon cap over which the control lever operates with ease and positive positioning security. Adopted as stand-



LEASHED

as the hawk is by jesses, the Douglas A4D Skyhawk bomb arming mechanism is leashed by one of over 5,000 special ball lock pins by Avdel. Special pins to your specifications in 4 to 6 weeks. Standard pins are now stocked for immediate delivery.

AVDEL INC.

210 S. Victory Blvd., Burbank, Calif.

Circle 549 on Page 19

46

Complete reprints of major articles now available from MACHINE DESIGN

USE THIS FORM TO ORDER YOUR COPIES TODAY!

Number Copies		Price Per Copy
____	ELECTRIC MOTORS	$1.00
____	ELECTRONIC AND ELECTRIC POWER SUPPLIES	1.00
____	FRICTION-CLUTCH TRANSMISSIONS	1.00
____	HUMAN-FACTORS ENGINEERING	1.00
____	DIRECTORY OF MATERIALS—18th Edition	1.00
____	PRODUCTION CHARACTERISTICS OF ENGINEERING METALS	1.00
____	DESIGN MANUAL ON ADHESIVES	1.00
____	NONMETALLIC GASKETS	1.00
____	ADJUSTABLE SPEED DRIVES (Electrical, Mechanical, Hydraulic)	2.00
____	ADJUSTABLE-SPEED ELECTRIC-MOTOR DRIVES	1.00
____	SPEED REDUCERS AND GEARMOTORS	1.00
____	INTERNAL COMBUSTION ENGINES	1.00
____	DESIGN FOR FATIGUE LOADING	1.00
____	WHY MACHINE PARTS FAIL	1.00
____	SIMPLIFIED VIBRATION ANALYSIS	2.00
____	DIMENSION CONTROL IN DESIGN	1.00
____	HYDRAULIC SERVO FUNDAMENTALS Vol. I	1.00
____	HYDRAULIC SERVO FUNDAMENTALS Vol. II	1.00
____	HYDRAULIC SERVO FUNDAMENTALS Vol. III	1.00
____	QUALITY CONTROL METHODS	1.00
____	MULTIPLE CIRCUIT SWITCHES	1.00
____	ELECTRICAL CONNECTORS	1.00
____	TRANSACTIONS OF THE FIRST CONFERENCE ON MECHANISMS	1.00
____	TRANSACTIONS OF THE SECOND CONFERENCE ON MECHANISMS	1.00
____	TRANSACTIONS OF THE THIRD CONFERENCE ON MECHANISMS	1.00
____	TRANSACTIONS OF THE FOURTH CONFERENCE ON MECHANISMS	2.00
____	TRANSACTIONS OF THE FIFTH CONFERENCE ON MECHANISMS	3.00
____	TRANSACTIONS OF THE SIXTH CONFERENCE ON MECHANISMS	2.00
____	MECHANISMS FOR INTERMITTENT MOTION	1.00
____	POLYDYNE CAM DESIGN	1.00
____	EVALUATING ENGINEERS	1.00
____	ENGINEERING MANAGEMENT	2.00
____	MEN AND MACHINES	1.00
____	DESIGNING WITH TEFLON	1.00
____	DYNAMIC SEALS AND PACKINGS	1.00
____	MECHANICS OF VEHICLES	2.00
____	TIPS AND TECHNIQUES—VOL. I (Drafting Aids)	1.00
____	TIPS AND TECHNIQUES—VOL. II (Engineering Aids)	1.00
____	PLANNING NEW PRODUCTS	3.00
____	DESIGN GUIDE FLEXIBLE COUPLINGS	1.00
____	INSIDE THE ENGINEER	1.00
____	MOBILITY OF CROSS-COUNTRY VEHICLES	1.00
____	HYDRAULIC LINES	1.00
____	1956-1959 DATA SHEETS (each)	2.00
____	THE FASTENERS BOOK	2.00
____	THE SEALS BOOK	2.00

MACHINE DESIGN

Reader Service
Penton Building
Cleveland 13, Ohio

TOTAL COPIES_____ TOTAL ORDER $_____

Remittance or Company Purchase Order must be enclosed with order.

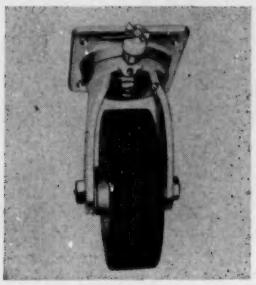
NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE_____ STATE_____

(Add 3% to orders in Ohio to cover State Sales Tax)



ard swivel-lock construction, casters are produced as one, two, three, or four-position lock models to suit specified need. **Albion Industries Inc.**, Albion, Mich.

Circle 781 on Page 19

Silicone Potting Material

has useful temperature range of −65 to +175 C

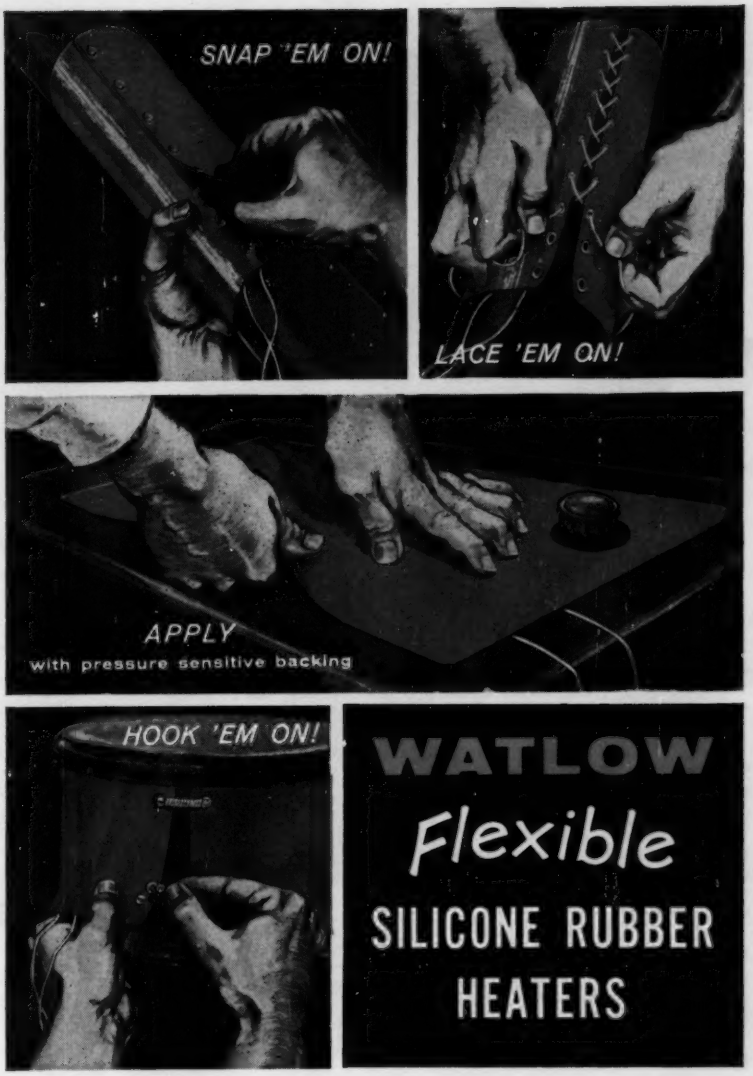
LTV 602 clear silicone potting and embedding compound provides mechanical and dielectric protection for electronic components and assemblies. It cures at 70 to 80 C to a flexible, resilient solid. Cured material is self-supporting and nonflowing, providing for ease of handling as well as continual exclusion of dust and other contaminating particles. Components imbeded in the material can readily be identified, repaired, or replaced by removal of a section with a sharp instrument. New material can be poured into the cutout section and cures without leaving evidence of repair. Because of its low viscosity in uncured form, compound flows freely in and around complicated parts. Delicate parts are not damaged by stress during cure. Material has excellent resistance to thermal shock, moisture, and complete water immersion. Useful temperature range is −65 to +175 C. **Silicone Products Dept., General Electric Co.**, Waterford, N. Y.

Circle 782 on Page 19

Control Valves

for pressures from 29 in. Hg vacuum to 250 psig

Mechanically or manually operated valves control air, oil, or vacuum. They are ¼-in. NPT, two-position, balanced-spool valves available in normally closed or normally open,



Light weight, flexible, only .050" thick. Teflon leads standard, other types on request. Can be rated at any wattage or voltage. Varied heat distribution pattern possible. They are water resistant and easily applied to any plane surface.

For Literature, Send Coupon Below

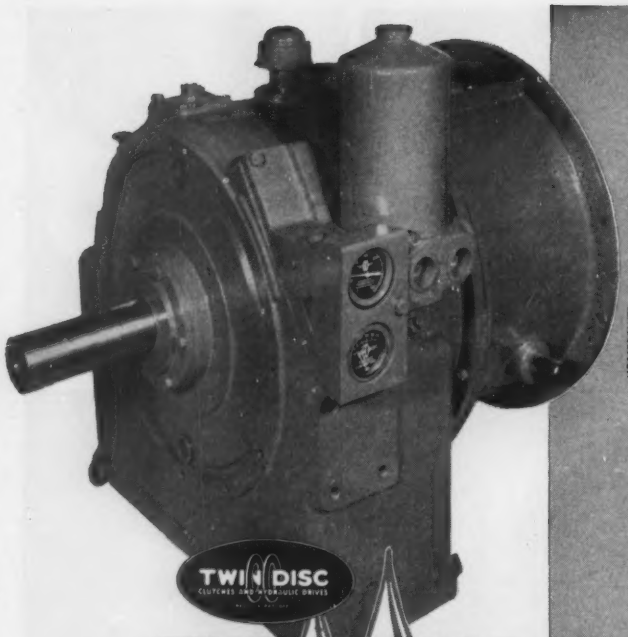
WATLOW
ELECTRIC MANUFACTURING CO.
1384 Ferguson Ave. / St. Louis 14, Mo.

6035

WATLOW ELECTRIC MFG. CO.
1384 Ferguson Avenue
St. Louis 14, Missouri

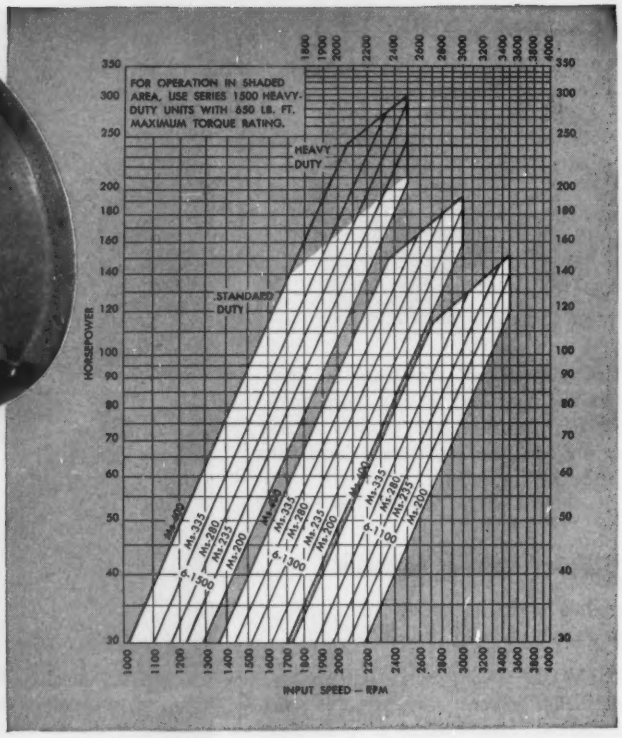
NAME.....
FIRM.....
ADDRESS.....
CITY.....ZONE.....STATE.....

Circle 551 on Page 19



TWIN DISC

Torque Converters


FOR OPERATION IN SHADED AREA, USE SERIES 1500 HEAVY-DUTY UNITS WITH 650 LB. FT. MAXIMUM TORQUE RATING.
HEAVY DUTY
STANDARD DUTY
HORSEPOWER
INPUT SPEED — RPM

This chart gives horsepower and speed ratings for all Twin Disc Single-Stage Converters. Note that the 1500 Series is furnished in standard and heavy duty capacities. The figure "6" preceding the series number refers to the type of circuit.

"Stripped" or cartridge-type units for OEM in-line design

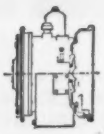
Nine models—11", 13" and 15" sizes.
Torque ratings from 235 to 650 lb.-ft.
Three types: Converter only; converter with oil-actuated disconnect clutch; and converter with disconnect clutch and lock-up direct drive clutch.

Basic power take-off units

Three models—13" and 15" sizes.
Torque ratings from 350 to 650 lb.-ft.
Suitable for side loads.

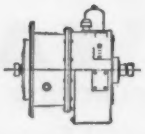
Spacer units for connection to transmissions

Three models—13" and 15" sizes.
Torque ratings from 350 to 650 lb.-ft.
Flanged output shaft.
Available with dummy flywheel for automotive type clutches.



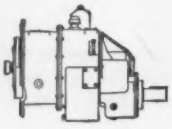
Units equipped with front-end disconnect clutch

Four models—13" and 15" sizes.
Single or double plate clutch.
Torque ratings from 350 to 650 lb.-ft.
Suitable for side loads.
Optional: Boom lowering freewheel for shovels and cranes.



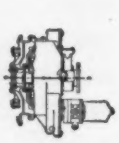
Units equipped with disconnect clutch plus 2:1 ratio reduction gear

Three models—13" and 15" sizes.
Single or double plate 11" clutch.
Torque ratings from 350 to 650 lb.-ft.
Suitable for side loads.
Optional: Boom lowering freewheel.



Sumpless PTO units for power-shift transmissions

Three models—13" and 15" sizes.
Live power take-off for auxiliary drives.
Torque ratings from 350 to 650 lb.-ft.
Flanged output shaft.
Optional: Rubber block input drive.



SINGLE-STAGE TORQUE CONVERTERS

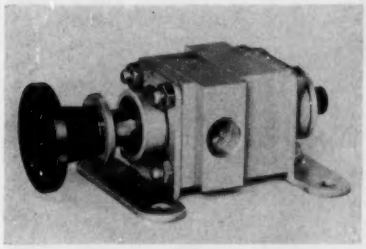
25 models

Virtually any single-stage torque converter requirement can be met with one of Twin Disc's standard rotating-housing units. The scope of the Twin Disc line can be seen from the summarized listing at left.

Each converter size—11", 13" and 15"—has five interchangeable impellers which vary with respect to blade number and pitch so that each has a different torque absorption capacity. This exclusive Twin Disc design feature provides a 2:1 horsepower spread for each converter series. It insures correct matching of converter to engine and also permits a subsequent increase in engine horsepower without dimensional changes in the torque converter.

Twin Disc Single-Stage Converters are available as "industrial" (self-contained) units or as "stripped" (cartridge type) units for incorporation into OEM transmission designs. Complete details are contained in Bulletin 510. For your copy, write TWIN DISC CLUTCH COMPANY, Hydraulic Division, Rockford, Illinois.

Circle 552 on Page 19



two, three, or four-way styles. Manual and mechanical operators include knob operators, lever, clevis, roller cam, overriding roller cam, foot pedal, treadle, and air operators. Valves are designed for pressures from 29 in. Hg vacuum to 250 psig. Modular design permits thousands of variations in valve styles, utilizing less than 50 standardized, interchangeable parts. **Hoffman Valves Inc.**, 2360 W. Dorothy Lane, Dayton, 39, Ohio.

Circle 783 on Page 19

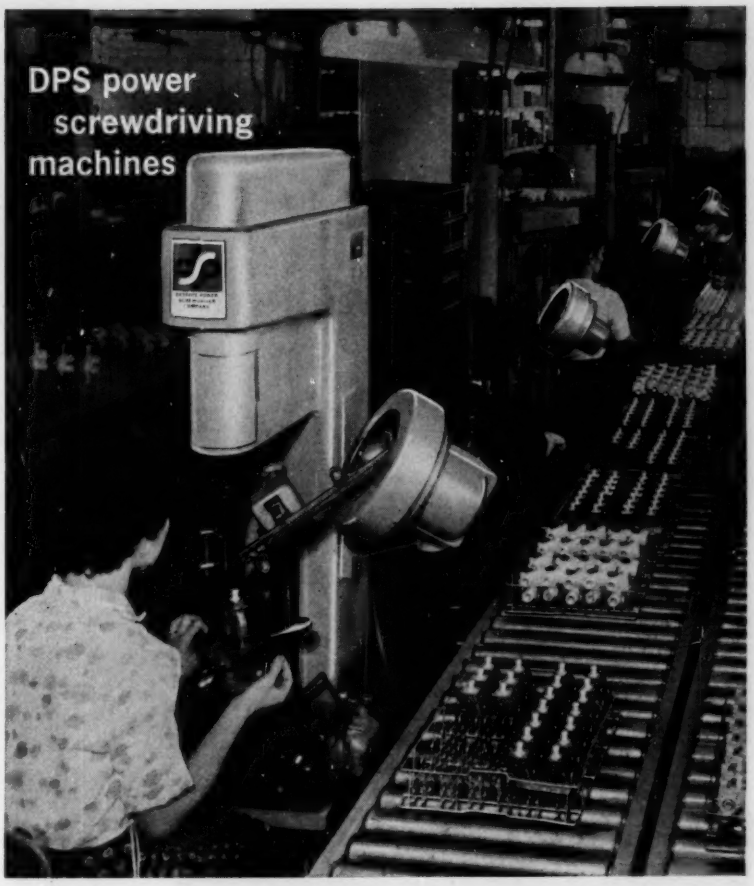
Bearing Take-Up Frames

accommodate any bearing in two-bolt pillow block

Multibearing take-up frames are available from stock in 11 sizes. They accommodate any type of bearing in any two-bolt pillow block with mounting holes to $\frac{5}{8}$ in. Frames allow horizontal bearing adjustments from 6 to 24 in. and mount 143 different bearing shaft sizes from $\frac{5}{8}$ to 2-7/16 in. diam. Mounting pads are easily adjusted to the mounting holes in the pillow block. Mounting flexibility permits

each size of take-up frame to accept a wide range of pillow-block bore sizes. All-steel frames have strong channels that form a rugged box frame with high rigidity. **Link-Belt Co., Dept PR**, Prudential Plaza, Chicago 1, Ill.

Circle 784 on Page 19



drive screws and nuts fast . . .
mar-free and accurately

Something as small as an inaccurately driven screw or nut can cause parts to be rejected. And that costs you money both in parts waste and time lost.

DPS Model U power screwdriving machines drive screws and nuts with the accuracy that improves assembly quality, reduces rejects. They give you speed, too. Drive up to 40 screws or nuts per minute.

The Model U is available in two types . . . pedestal and self-contained driving head. Both require only a minimum of space and are easily adaptable to your work flow. Feeder mounts on either side of machine column for right- or left-hand assembly. Other features include a positive control clutch which maintains constant driving torque, motorized hopper drive with safety clutch, and fully adjustable feed track and escapement mechanism.

DPS Model U drives screws from #6 x 3/16" long to 1/4" x 1 1/2" long and can be equipped with 12" or 16" rotary feeders. Write for Model U bulletin.

15,803

DETROIT POWER SCREWDRIVER CO.

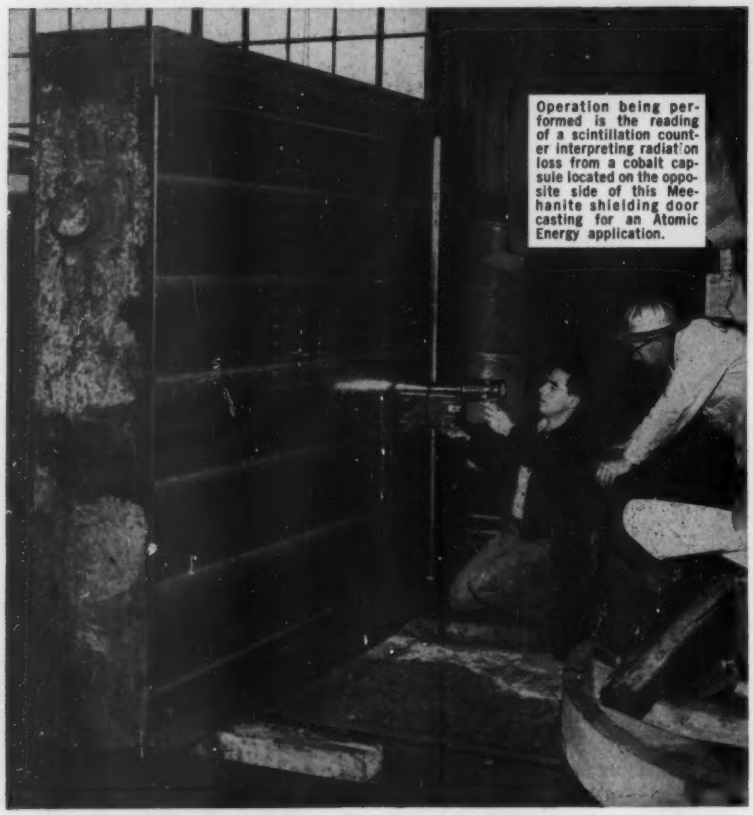
A Subsidiary of Link-Belt Company

Selective Parts Feeders; Screw, Nut and Stud Driving Machines; Special Purpose Assembly Machines

2801 W. Fort Street
Detroit 16, Michigan
TAshmoo 5-3070

Circle 553 on Page 19

MEEHANITE® MEANS BETTER CASTINGS


Operation being performed is the reading of a scintillation counter interpreting radiation loss from a cobalt capsule located on the opposite side of this Meehanite shielding door casting for an Atomic Energy application.

Specify Meehanite® For High Density And Solidity In Heavy Sections

Dimensions of the 85,000 lb. Meehanite casting above are 12'6" x 12'6" x 12" thick. Specific gravity tests, ultrasonic and radiation loss readings verify its uniform and controlled density.

In massive castings of this type which have a slow cooling rate, there is a natural tendency towards a more open structure with a corresponding loss in strength. However, in Meehanite castings the effect of "mass influence" is minimized through the use of constitutional carbide controls which are exclusive to the Meehanite Process. Breakdown of structure due to slow cooling is avoided by providing a definite degree of undercooling of the graphite to the melt.

In specifying the correct type of Meehanite metal for castings with very heavy or very light sections, the effect of mass influence should always be considered.

For detailed information, send for a free copy of bulletin TD-14-EFFECT OF MASS INFLUENCE. Write: Meehanite Metal Corp., New Rochelle, N.Y.

MEEHANITE METAL

Meehanite Castings Are Made Only By Meehanite Foundries

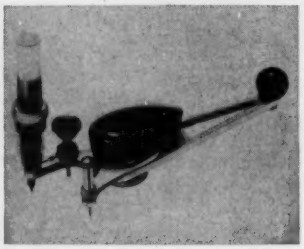
ENGINEERING DEPARTMENT

EQUIPMENT

Reservoir Pen

has visible ink supply

Leroy reservoir pen holds enough ink to draw a straight line approximately 1200 ft. Ink supply is contained in an airtight, nonporous, translucent cartridge, and is always visible. Built-in weighted needle assures clean passage of ink from reservoir to point. Light vertical shaking of the pen sets needle in motion, removing particles that may



have settled in the tube when pen is not in use. Needle also provides efficient cleaning action when washing out the pen. Unit is available in seven point sizes from 00 to 5, and can be used with any Leroy lettering scriber. **Keuffel & Esser Co.**, Third & Adams Streets, Hoboken, N. J.

Circle 785 on Page 19

Miniature Vacuum Recorder

is available in two pressure ranges

New vacuum recorder, only 3⅝ in. wide x 5⅝ in. high, is suitable for bench, desk, or panel-mounted installations. Two pressure ranges, 0 to 1000 micron Hg and 0 to 20 mm Hg, are available. Reliability is excellent since full voltage regulation is incorporated in the circuitry. Gage tubes withstand shock and vibration without breakage. All tubes are matched and interchangeable, without readjustment or recalibration, and incorporate full temperature compensation. Opera-

Fights Flux Attack to Cut Brazing Costs

Because of the severe destructive effects of flux used in aluminum and copper brazing processes, proper alloy selection and quality construction are the only answers to long belt life in this type of operation. Cambridge Cambriloy 35-19 Metal-Mesh Belts have successfully withstood flux attack in many copper brazing installations for as long as 6000 hours, giving users continued production of quality parts while cutting operating and maintenance costs.

There is a complete line of Cambridge Belts in special and standard metals and alloys to meet your specific requirements—custom built in any weave to insure the most efficient processing.

Experienced Cambridge Field Engineers—experts in their field—are available to discuss your needs and help you select the best belt suited to your operations. Or, they can offer you sound advice on the installation, operation and maintenance of your Cambridge Belts. Talk to your Cambridge man soon. He's listed in the Yellow Pages under "Belting, Mechanical." Or, write for free 130-page reference manual.

The Cambridge Wire Cloth Co.

DEPARTMENT N • CAMBRIDGE 3, MARYLAND

Manufacturers of Metal-Mesh Conveyor Belts, Flat Wire Conveyor Belts, Wire Cloth, Wire Cloth Fabrications, Gripper® Metal-Mesh Slings

Circle 555 on Page 19

NOW... STOCK SPIRAL BEVEL GEARS TO CUT COSTS

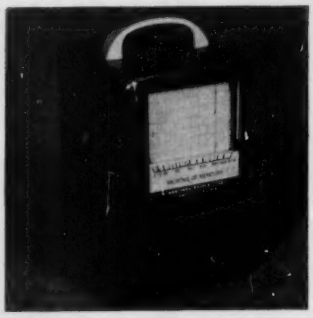
Now for the first time Perkins offers a complete line of stock spiral bevel gears with precision quality to help you get maximum savings in tooling expense and gear cost. When you're planning for spiral bevel gears, design your requirements around this Perkins stock line . . . it can pay you well.

Perkins stock spiral bevel gears have soft bores and may be reworked to a maximum diameter. The gears are matched in pairs and lapped together after hardening for smooth running. In many cases these gears are available in left and right hand drives. This new line of stock gears includes the most commonly used ratios and sizes proportioned according to the Gleason Spiral Bevel Gear System.

AVAILABLE ON REQUEST:

This new folder includes all standard specifications of Perkins complete line of stock spiral bevel gears. Write for folder No. 13.

PERKINS
MACHINE AND GEAR CO.
WEST SPRINGFIELD, MASS., U.S.A.



tion is from 115 v ac, 60-cycle line. Chart paper and recorder scales are calibrated directly in absolute pressure units. Calibration is unaffected by exposure to, or changes in, atmospheric pressure. **Hastings-Raydist Inc.**, Hampton, Va.

Circle 786 on Page 19

Ceramic Cement

retains strength over −320 to +1800 F range

Type 64CP ceramic element bonds temperature or strain-gage transducers to metallic or nonmetallic surfaces. Properties of the cement make it suitable for applications involving electrical insulation of transducers and lead wires, bonding components to structures subject to mechanical and thermal stress, and thermal barrier requiring rigidity and strength. Cement retains strength and major electrical properties over temperature range of −320 to +1800 F. It is composed entirely of inorganic materials, is nontoxic, and chemically inert to LOX. Porous and hygroscopic when hardened, it can be coated with silicone varnish to waterproof the installation. **Trans-Sonics Inc.**, P. O. Box 328, Lexington, 73, Mass.

Circle 787 on Page 19

Torque Gages

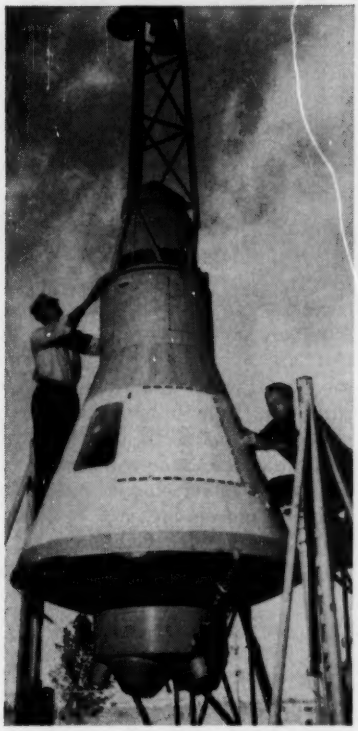
are accurate to ±1 per cent

TGRL torque gages measure starting, stalling, and friction torques on small instruments and miniature motors. Design of the gages permits clockwise or counterclockwise torque to be registered in the same direction on the same scale. Each unit is individually calibrated for each application and is completely mechanical and nonmag-

Circle 556 on Page 19

THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING



NO PLACE FOR AN ACROPHOBE

When first we read of the seven who are eager to blaze a route to the stars, we pondered what we thought of as man's inborn fear of great heights.

Now we learn that the first of the astronauts will have a window in his capsule, that he will peer *down* at the spinning earth and *out* at the wheeling stars.

We are producing these unique, space-going viewports for McDonnell Aircraft Corporation, prime contractor for the National Aeronautics and Space Administration's Project Mercury capsule.

The window is an excellent piece of engineering. Not just because we made it, but because it *has* to be.

It will take the slams and whams, the blistering heat, and the embrittling cold of blast-off, orbitation, re-entry, and a soak in the briny. All during this it must remain transparent, intact, and sealed tight.

There are four panes to the window. The outer two are VYCOR® 96% silica glass. The inner two are aluminosilicate glass specially tempered to phenomenal strength.

Each pane is ground and polished to the precision finish of a telescope mirror. The outermost panel curves to the contour of the capsule, so it trapezoids from an 11″ base to a 7½″ top along a 21″ height.

The glasses present a delicate balance of optical qualities, thermal shock resistance, and low weight. The last is vital when you consider that it takes about 100 gm of fuel to orbit 1 gm of payload.

So, remember, when you see the first astronaut smiling quietly, confidently from his capsule, you are looking at him through Corning glass.

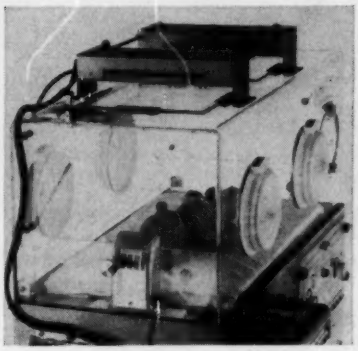
HOW ABOUT A DEGREE IN MEDICAL ENGINEERING?

The mechanics of modern medicine are fast maturing to the point where some engineers are specializing in the building of machines like this Infant Servo-Controller for the Isolette, manufactured by Air-Shields, Inc., Hatboro, Pennsylvania.

This particular machine is used with prematurely born infants who must keep their body temperature at a constant level, but lack a well-developed thermal regulatory device.

You attach a thermistor to the babe's abdomen and let him work as his own thermostat. He automatically requests heat from infrared lamps whenever his skin temperature drops below 97°F. When things are just right again, he switches off the lamps and takes a rest, with the odds for survival more in his favor.

If you've ever tried to unbulb an infrared lamp, you know that it gives off *direct* heat as well as IR energy.

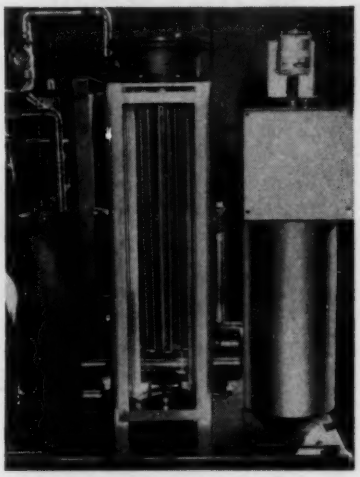


That's why there are two PYREX No. 7740 glass plates sitting on top of the plastic chamber in the picture. You can see them, if you look closely. The PYREX plates are heat resistant and will also dissipate the *direct* thermal output of the lamps. So, the plastic forgets the lamps are there.

As far as the IR energy is concerned, the PYREX plates don't exist either, so practically all the IR gets through to the baby.

The over-all relationship between IR and glass is an odd one. We can give you glass which transmits as much as 92% of the IR or a glass which transmits as little as 8% of the IR.

Happily for our product specialists, there is demand for both situations. We've prepared some bulletins on many of these IR characteristics, a copy of which you may have by sending the coupon.



SOMETIMES GLASS IS SO OBVIOUS

Leafing our way through the 4th Annual Shirt Issue of "Cleaning Laundry World" (April 1960), we took note of an advertisement which concerned a machine which displayed a feature which we consider the soul of genius.

The machine is a dry cleaner manufactured by Detrex Chemical Industries, Inc. The feature is a glass-enclosed filter which keeps the dry-cleaning solvent cycling unpolluted. The soul of genius, to our minds, consists of intelligent manipulation of the obvious . . . in this case, an application of the first known and longest respected of the myriad properties of glass . . . to wit, its *transparency*.

When you locate such a place, it doesn't necessarily take a lot of redesigning of custom fabrication to put glass to work, either. We checked and found that Detrex, for example, simply orders standard 6″ O.D. PYREX brand Heavy Duty Tube for its filter wall.

The result is that the operator of the Detrex Cleaner can watch the filter at work. He can spot trouble while it's still potential, determine its cause exactly should it occur . . . all without any dismantling or shutdown.

Is there anything you're working on that you wish you could watch working? If there is, and you want to put glass to work, you can start by sending the coupon for a copy of Bulletin IZ-1, "Designing with Glass for Industrial, Commercial, and Consumer Applications."

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS, 523 Crystal St., Corning, N. Y.

☐ IR Transmitting Glasses ☐ IR Reflecting Glass ☐ IZ-1

Name..... Title.....

Company.....

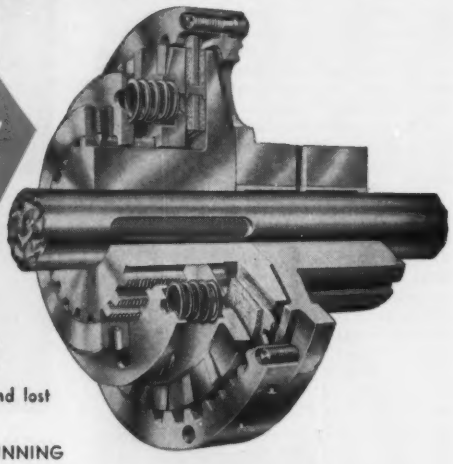
Street.....

City..... Zone..... State.....

Circle 557 on Page 19

HILLIARD *Clutches*
FOR POWER CONTROL DESIGN

ADJUSTABLE *Slip Clutch*



- PROTECTS against overload, jams and down time.
- RESUMES THE DRIVE AUTOMATICALLY after overload.
- ELIMINATES SHEAR PINS and lost time.
- ADJUSTABLE - WHILE - RUNNING feature is available.

Hilliard Slip Clutches are continuously protecting the drive on dish washing machines—printing presses—packaging machines—case loaders—foundry equipment— air filters—conveyors—overhead doors—and many others.
They maintain steady torque while permitting speed variation on fabric drying drums, steel strip slitters and similar equipment.

The adjustable-while-running types are used to maintain constant tension on rewind stands for paper coaters, textile machines, rope, steel and wire mills and for drive systems requiring overload protection but which must be disconnected at times.

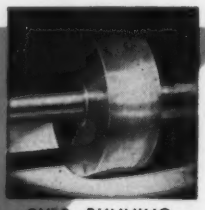
WRITE TODAY FOR BULLETIN 300 WITH COMPLETE INFORMATION.

● OTHER HILLIARD CLUTCHES ●

CONSIDER AUTOMATION - INVESTIGATE THESE PRODUCTS

SINGLE REVOLUTION CLUTCHES for automatic accurate control—electrical or mechanical—of intermittent motion, indexing, cycling and cut-off. Ask for Bulletin 239.

HILLIARD - TWIFLEX CENTRIFUGAL COUPLING for smooth, easy starting of any load automatically with overload protection and ability to accommodate shaft misalignment. Ask for Bulletin CE-3.



OVER - RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet, or backstop action. Ask for Bulletin 231.

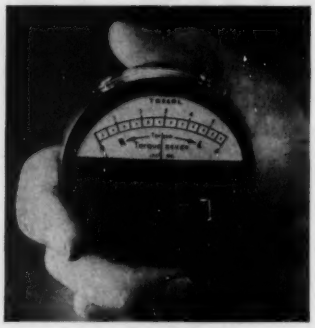
THE HILLIARD *Corporation*

MANUFACTURING CLUTCHES FOR OVER 50 YEARS

103 WEST FOURTH ST., ELMIRA, N. Y.

IN CANADA: UPTON • BRADEEN • JAMES, LTD.

Please direct inquiries to advertiser, mentioning MACHINE DESIGN



netic. Gages are suitable for measuring positioning servomotors, detent-type servomotors, gimbal assemblies, and small gear trains. They are accurate to ±1 per cent, and are available in 5 and 7-oz models. Eight standard ranges are furnished, from 0-2 oz-in. with 1/8 oz-in. increments on one scale, to a high of 144-216 oz-in. with 1/2 or 1 oz-in. increments on one scale. **Torque Controls Inc.**, 829 E. Broadway, San Gabriel, Calif.

Circle 788 on Page 19

Dial Indicator

has accuracy of ±0.00001 in.

No. 25-106 Dial-Master dial indicator is designed for applications requiring extreme precision, such as inspection to laboratory standards or laboratory work. Indicator has accuracy of ±0.00001 in. Widely spaced graduations read in 0.00005 in., and dial reading is 0.0015-0-0.0015 in., with a total range of 0.003 in. Dial indicator is furnished with jeweled bearings only. **L. S. Starrett Co.**, Athol, Mass.

Circle 789 on Page 19

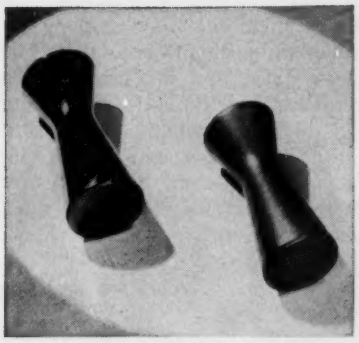
Tracing Vellum

has high tear strength and transparency

Ozatrace tracing vellum is used as a durable tracing paper, and for type-on masters for whiteprint, letterpress, or offset reproduction. It is available in white with a green tint to prevent glare. Formation is closed, dense, and uniform to provide a good drafting surface, even penetration of transparentizer, and sharp reproductions. Transparentizer is a water clear, synthetic, inert, solid resin. In combination with base paper, it transmits light

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **Matte finish for molded parts**
- **Phenolic for blowers**
- **Fire-safe, bakable reinforced polyester**



NORTON LABORATORIES, INC.

Want less gloss?

For years we've trumpeted the virtues of the high gloss that's characteristic of phenolic molded parts.

Gloss, however, is not always a plus. In certain precision instruments, gloss translates into *glare*. Sometimes, too, a consumer product can gain esthetically from the satiny look and feel of a matte finish.

One custom molder, Norton Laboratories, Inc., has developed a special process for putting matte finishes on compression-molded phenolic parts, as on the double-duty lamp handle-switch above. In some instances, the finish takes the place of a painting operation and so lowers cost.

The plastic molder now supplying this type finish is Norton Laboratories, Lockport, N. Y. We suggest that you write to them directly for quotations on plastic parts you need incorporating this finish.

Move air at low cost

Note the economy of design in this blower and duct assembly for an automatic washer-dryer. Why use more pieces when three will do?

Note, too, how economy begets economy. Very few assembly operations. Few rejects, because these phenolic parts can't get bent and won't warp. No balancing needed in the blower wheel, because concentricity is molded in. Wobble is much less than could be achieved at low cost in a metal wheel.

Phenolic is functionally right for air-moving jobs, especially if they also involve heat: a small hair dryer, a big circulating fan, or just about anything between. Inexpensive general-purpose molding compound serves adequately, as a rule: withstands moisture and mild corrosive atmospheres; is unbothered by temperatures up to 300°F; even resists flame spread; operates for years without rattling, drumming.

Your molder of thermosetting plastics can probably help *you* achieve such economy, whether in a blower or some other part you're working on. To get more ideas on where and how to use phenolic molding compounds, send in the coupon, requesting Durez Bulletin D400.

The different polyester

Cutting across the currents and countercurrents of talk about reinforced polyester plastics are two incontrovertible facts:

1. You can get a polyester molding material that's *inherently and permanently self-extinguishing.*
2. This same polyester can take a baked-on finish without surface craze.

Its name is Hetron.® The self-extinguishing trait does not come about as a result of diluting the plastic's strength with additives. It's there to begin with, in atoms of chlorine welded tightly into the resin molecule. That's why it lasts.

So much for chemistry. The craze resistance takes longer to explain, but matched-die molders know they can count on it for structural shapes that must undergo a 90-minute bake at 350°F.

Superimpose these two truths on the other advantages of strong, lightweight polyester construction, and you can appreciate why Hetron is helping so many designers give shape to new ideas. This luggage pod for a jet airliner is one case in point. Others include 65-foot radomes, factory skylights, large boat hulls, outboard-motor shrouds, chemical ducts and vessels, transformer housings, heavy-duty switch-gear components.

If you'd like to know more about this versatile material, check the coupon for designer's Hetron data file.

For more information on Durez materials mentioned above, check here:

- ☐ Phenolic molding compounds (8-page Bulletin D400)
- ☐ "Durez Plastics News" (a review of current plastics applications, mailed bimonthly)
- ☐ Hetron polyester resin (data file and list of fabricators)

Check, clip and mail to us with your name, title and company address.
(When requesting samples, please use business letterhead)

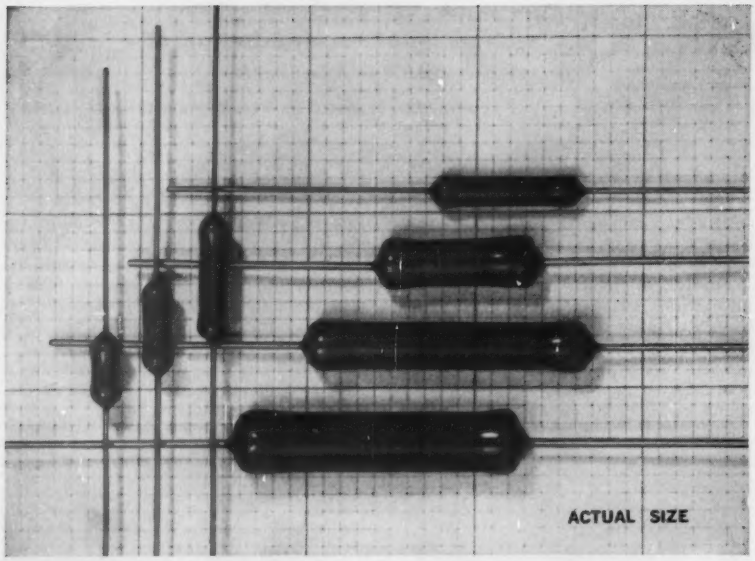
DUREZ PLASTICS DIVISION

503-1 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

Circle 558 on Page 19



THESE "WIRE-WOUNDS" ARE CIRCUIT SHRINKERS . . . . . *newly*

expanded line lets AXIOHM® power resistors go into smaller circuits!

Ward Leonard AXIOHM power resistors are now available in *seven* sizes—down to 2 watts, up to 12.5.

They're ideal for miniaturization in printed-circuits, industrial instrumentation and automation circuitry. But they're recommended for *any* electrical or electronic application where the highest stability and maximum overload capacity are required.

The seven AXIOHM sizes come in a complete range of resistance values (see table) from 0.1 to as high as 75,000 ohms. Naturally, they feature the qualities Ward Leonard has made famous in power resistors:

Vitrohm vitreous enamel; Ward Leonard's specially made ceramic core; specially selected and matched resistance wire; and strong, permanent, low-resistance, spot-welded, lead-to-end-cap junctions. O.9

SIZES AND RATINGS

Rating (in watts)	Type	Resistances (ohms)		Dimensions (inches)	
		Min.	Max.	Length*	Diam.
2	2X	0.1	5,000	3/8	3/16
3	3X	0.1	10,000	1/2	3/16
4	4X	0.1	15,000	11/16	3/16
5	5XM	0.1	20,000	15/16	3/16
7	7X	0.1	25,000	1	5/16
10	10XM	0.1	50,000	1 3/4	5/16
12.5	12.5X	0.1	75,000	1 3/4	3/8

*Less leads.

Get complete details in Supplement C to Catalog 15. Write for your copy and a list of stocking distributors today. Ward Leonard Electric Co., 58 South Street, Mount Vernon, New York. (In Canada: Ward Leonard of Canada, Ltd., Toronto.)

RESULT-ENGINEERED CONTROLS SINCE 1892

WARD LEONARD ELECTRIC CO. MOUNT VERNON NEW YORK

RESISTORS • RHEOSTATS • RELAYS • CONTROLS • DIMMERS

"Visit us at Booth 2231 at the IRE Show."

Circle 559 on Page 19

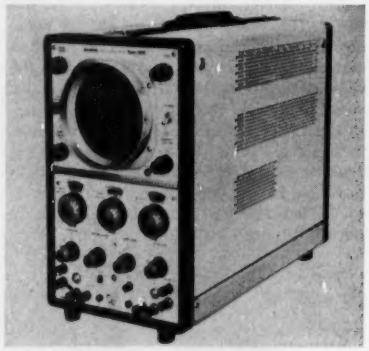
rapidly for fast, clear reproduction. Slightly textured surface in the base paper provides good pencil "take." Surface also accepts drawing ink without skipping, feathering, or spreading. Pencil lines can be erased from one spot at least ten times without damage to the drafting surface, and ink lines can be erased at least three times. Vellum has high tear strength. It is supplied in 16-lb weight, in 30, 36, and 42-in. rolls, and in all cut sheet sizes. **Ozalid Div., General Aniline & Film Corp.,** 50 Corliss Lane, Johnson City, N. Y.

Circle 790 on Page 19

Dual-Trace Oscilloscopes

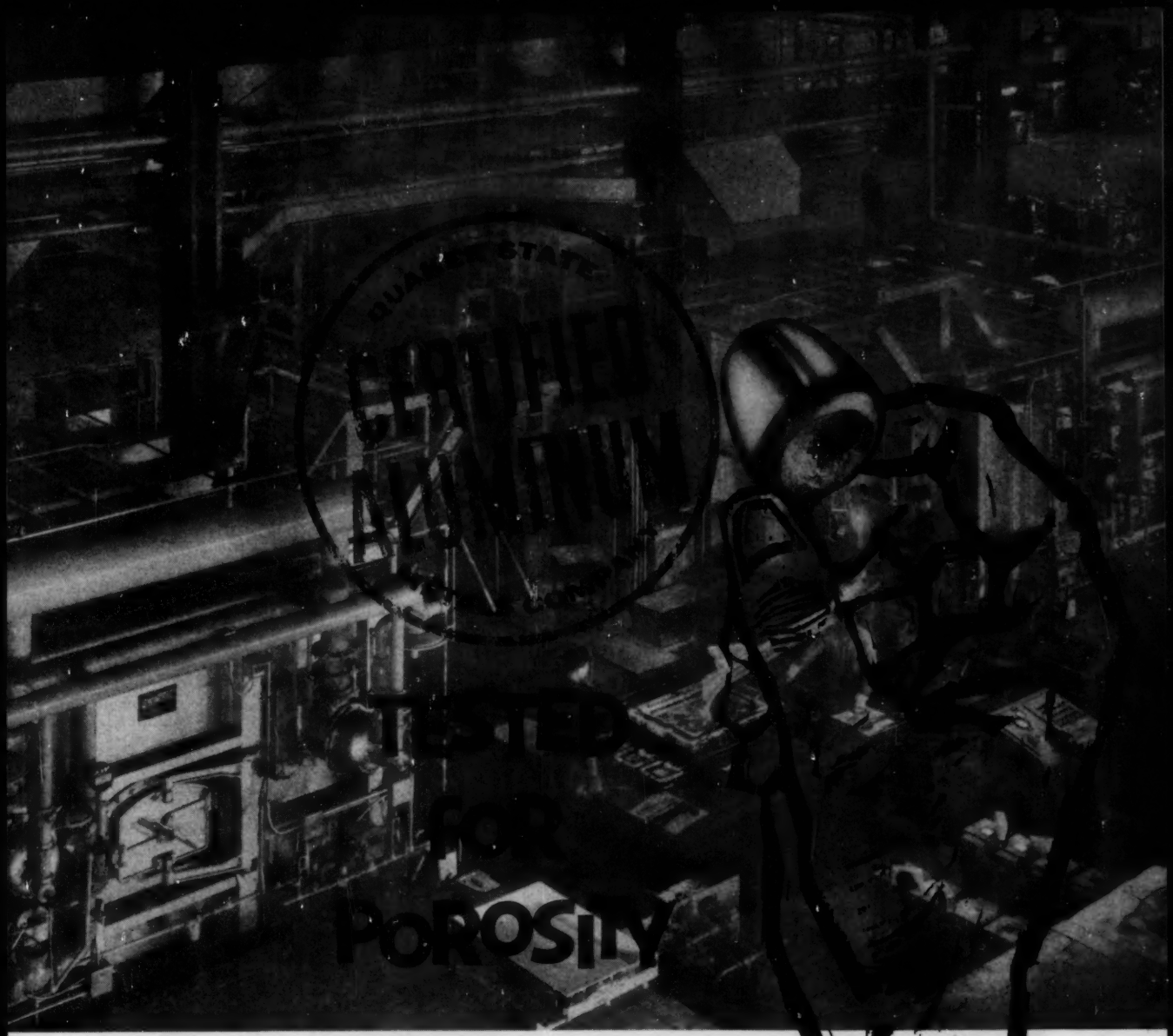
have 64 contacts to mate with plug-in circuits

Two dual-trace oscilloscopes, Type 1120 (portable) and 1120-R (rack-mountable), permit the simultaneous display of two vertical signals against time, against each other



(X-Y plots), or versus a third variable fed externally to the X-axis. Main-frame indicators have 64 contacts to mate with plug-in circuits. Electronic switching circuitry for dual-trace presentations is included in the main frame, achieving dual-trace presentations with all Analab plug-in units. Oscilloscopes have a frequency response of dc to 500 kc (3 db) and 10 cm undistorted deflection at 1 mc, and sensitivity without plug-ins of 40 mv per cm and 400 mv full scale. Units are designed for safe off-ground operation to 500 v dc. They are specified for high-altitude operation to 10,000 ft. **Analab Instrument Corp.,** 30 Canfield Rd., Cedar Grove, N. J.

Circle 791 on Page 19



Now you will have written assurance of quality that adheres to your specifications when you buy from Quaker State. During the melting and through every step in processing, QSM metallurgists and technicians test and inspect your order to be certain that it is filled according to your specifications and will meet our exacting standards of quality.

TESTED FOR POROSITY—One of the specific tests metal must meet, the test for porosity is made before a rolling ingot is cast. It assures you of aluminum that is free of gas pockets that would adversely affect the working qualities of the finished material.

QSM

HOWE SOUND COMPANY

QUAKER STATE METALS COMPANY

Lancaster, Pennsylvania

A DIVISION of HOWE SOUND COMPANY

Mill Producers of Aluminum Sheet, Coil, Tubing and Extrusions

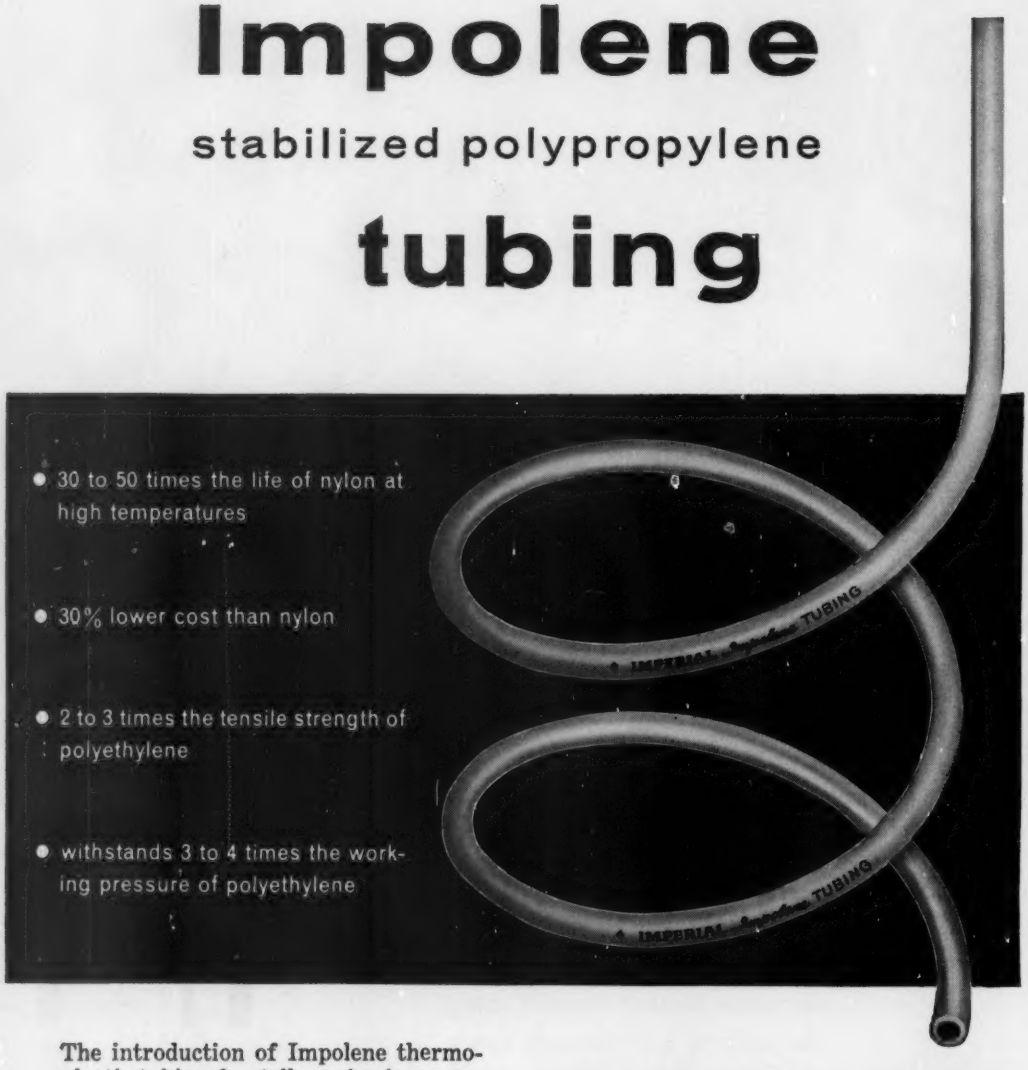
Circle 560 on Page 19

new

Impolene

stabilized polypropylene

tubing


• 30 to 50 times the life of nylon at high temperatures
• 30% lower cost than nylon
• 2 to 3 times the tensile strength of polyethylene
• withstands 3 to 4 times the working pressure of polyethylene
IMPERIAL Impolene TUBING
IMPERIAL Impolene TUBING

The introduction of Impolene thermoplastic tubing foretells major improvements in the transmission of air and fluids. This Imperial-Eastman stabilized polypropylene tubing now has many proved uses. Many more await it. What's yours? For complete data, write for Impolene Bulletin No. 301.

IMPOLENE

IMPERIAL EASTMAN

Imperial-Eastman Corporation General Offices: 6300 West Howard Street, Chicago 48, Illinois

In Canada: Imperial-Eastman Corporation (Canada) Ltd., P.O. Box 645, Barrie, Ontario

Circle 561 on Page 19

new
Impolene
with *new* advantages, many *new* uses

High tensile strength. Highest strength-to-weight ratio of all thermoplastic tubing. Working pressures compare favorably with nylon—are 3 to 4 times greater than polyethylene.

Excellent corrosion-resistance. Resists concentrated hydrochloric acid up to the boiling point. Withstands saline solutions at temperatures over 212° F. Shows no detrimental effects in boiling sulfuric acid.

Wide temperature range. Can be used up to 300° F. Has 30 to 50 times the life of nylon at elevated temperatures. Remains flexible at —100° F.

Good abrasion-resistance. High surface hardness gives it much better abrasion-resistance than most thermoplastics.

Ordorless . . . tasteless . . . resists sunlight. Approved by the FDA and NSF for food and drinking water applications.

Use Impolene tubing for air lines, control panels, instrumentation and lubrication systems, processing and construction machinery—many other uses.

Available in 500' to 1000' spools in O.D. from ⅛" to ⅜". Other sizes available on special order.

Poly-Flo Fittings—designed for use with all plastic tubing, yet usable with soft metal tubing. Withstand pressures beyond burst strength of tubing. Available in a complete range of sizes and styles.

Now Imperial-Eastman meets all your requirements for hydraulic-pneumatic-flow system components: tube fittings, valves, couplings, flexible and rigid hydraulic and pneumatic lines, thermoplastic tubing, tubing tools.

TUBING

IMPERIAL — EASTMAN

THE ENGINEER'S Library

Recent Books

Introduction to the Kinematic Geometry of Gear Teeth. *By Allan H. Candee; 204 pages, 6¼ by 9½ in., clothbound; published by Chilton Co., Book Div., 56th and Chestnut Sts., Philadelphia 39, Pa.; available from* MACHINE DESIGN, *$12.50 per copy postpaid.*

Principles of gear design are presented with emphasis on gear-tooth contact. Only tooth contact between profile curves in cross sections of teeth is considered. Discussion applies mainly to gears on parallel axes.

A graphical method is utilized to solve problems. It consists of geometrical constructions by lines and points combined with numerical calculations of distances and angles. Concepts of instant centers and centers of curvature are stressed.

Organizing the Technical Conference. *By Herbert S. Kindler; 139 pages, 6¼ by 9¼ in., clothbound; published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; available from* MACHINE DESIGN, *$6.00 per copy postpaid.*

Duties and activities of the organizing committee are charted and discussed in this working manual. Aspects of programming, promoting, documenting, administering, and evaluating various kinds of professional meetings are explained.

Key factors that contribute to a successful conference are analyzed and interpreted. Unique problems posed by the various meetings are discussed.

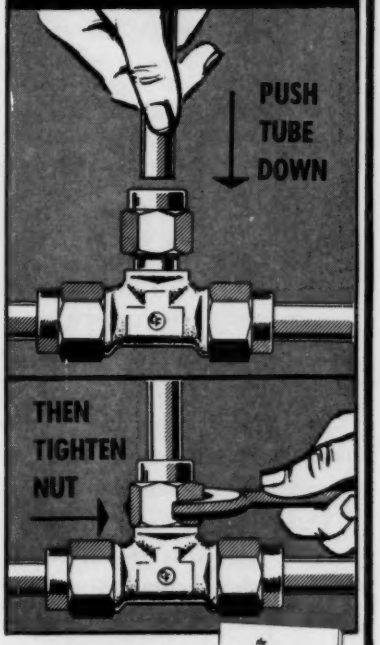
Fuel Cells. *Edited by George J. Young, associate professor of physical chemistry, Alfred University; 154 pages, 6¼ by 9¼ in., clothbound; published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; available from* MACHINE DESIGN, *$5.75 per copy postpaid.*

This book covers design and principles of operation of hydrox, carbox, and other types of fuel cells. Material is based on a symposium sponsored by Gas and Fuel Div. of

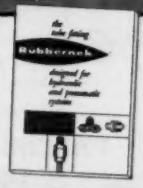
CHICAGO FORGING'S NEW **Rubbernek** FITTING *designed to* SAVE ON ASSEMBLY ABSORB VIBRATION

UNIQUE, IMPROVED DESIGN makes Rubbernek the most versatile of fittings. Helps you design better pneumatic and fluid circuits. Provides simplest, fastest assembly. Gives foolproof sealtight installations for pressure or vacuum. Complete line of factory-assembled fittings in standard sizes now available from stock. Test run Rubbernek in your own plant. Consult our engineers

Just 1-2 and you're thru!



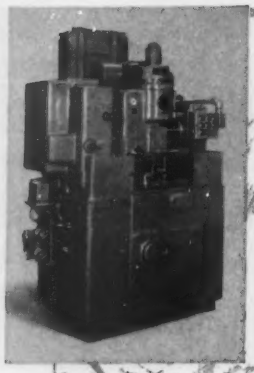
Write for Free NEW RUBBERNEK Catalog No. 161 Dept. M.



Some choice territories open for representation.

CHICAGO FORGING & MANUFACTURING CO.
2004 SOUTHPORT AVENUE
CHICAGO 14, ILLINOIS

Circle 562 on Page 19



designed with a
GEAR-SHAPER
in mind!

It's *practical* and *economical* to produce odd-shaped parts on a Fellows Gear Shaper.

Merely by using special cutters and fixtures on *standard* Fellows machines, an almost limitless variety of internal and external contours can be generated. In many cases, a single set-up does what ordinarily would require several conventional shop operations.

And, of course, *standard* Fellows generating equipment also provides high production of internal and external spur and helical gears, from "miniatures" up to 120 inches OD.

This versatile production method is fully described and illustrated in "The Art of Generating with a Reciprocating Tool." Send for your free copy of this informative booklet.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont, U.S.A.
Branch Offices:
1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N. J.
5835 West North Avenue, Chicago 39
6214 West Manchester Ave., Los Angeles 45

THE PRECISION LINE

Fellows *Gear Production Equipment*

American Chemical Society. Contributing authors examine industrial implications of fuel cells as ground power supplies, as power supplies for mobile engines, and as chemical reactors.

The Finn Magnus Story. *By Mark Hunter; 485 pages, 5¾ by 8¾ in., clothbound; published by Odin Press Inc., 122 East 42nd St., New York 17, N. Y.; available from* MACHINE DESIGN, *$6.95 per copy postpaid.*

This account shows how Magnus developed the principles that helped him create more than 40 successful mass-production items and found two new industries. His fundamentals of product design are explained —and demonstrated with actual case studies.

The Measure of Man: Human Factors in Design. *By Henry Dreyfuss; 34 pages, 9½ by 12¾ in., hard cover; published by Whitney Library of Design, 18 East 50th St., New York 22, N. Y.; $4.95 per copy.*

This publication contains various diagrams illustrating the essential measurements of the human male and female figures. Two life-size diagrams are included—one male and one female.

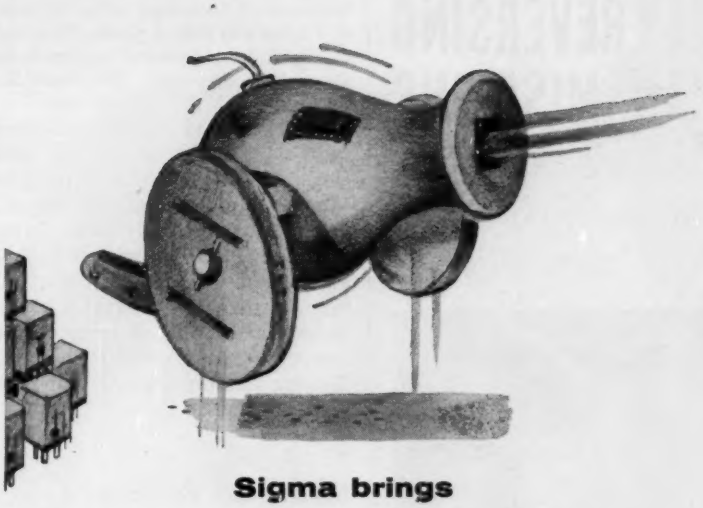
Supplementary information includes explanations of measurements, a checklist, and a bibliography. Diagrams were developed in the course of designing machine tools, missile systems, interiors of airplanes and marine equipment, and industrial and farm equipment.

Basics of Analog Computers. *By T. D. Truitt and A. E. Rogers; 400 pages, 6¼ by 9¼ in., clothbound; published by John F. Rider Publisher Inc., 116 W. 14th St., New York 11, N. Y.; available from* MACHINE DESIGN, *$12.50 per copy postpaid.*

Concepts, devices, and applications of the analog computer are presented in detail. More than 400 illustrations pinpoint ideas discussed in the text.

Text material is divided into three sections: 1. Analog-computing principles and techniques. 2. General-purpose analog computers. 3. Using the dc-analog computer. Knowledge of computers is not presupposed.

Introduction to the Statistical Dynamics of Automatic Control Systems. *By V. V.*



Sigma brings big gun to bear on commercial relay field

There's a new Sigma relay just coming into the picture that's so disarmingly simple in design, construction and operation that Believers in Complexity will probably get mad when they see it. (After all, if you give someone a simple answer to anything nowadays they think that you couldn't possibly have understood the problem.) But the reaction around here is that the designer's really got something, and there was even talk about erecting a small monument to him in the parking lot.*

We were going to call this new general purpose AC-DC relay the "Series 90" until there was some rumbling in the number department, so now it has the much more economical, sensibly conservative number of 46. It's an honest-to-goodness *good* heavy duty commercial relay, that will switch up to 10 amp, 120-volt resistive loads on as little as 200 mw. DC or 0.5 v-a AC. What the big simplicity pitch Means To You is that there are so few parts it's almost impossible for anything to get out of whack; the few parts it *does* have aren't hard to make or assemble (translated, $3 or $4 per relay in quantity); a big motor and fat DPDT contacts efficiently use every bit of the volume and give a long mechanical life — from 500,000 operations on 10 amp loads to 10 million operations at no load. Since we hope the "46" will find its way into such things as machine tool controls, timers and laundry equipment (and even smarter Electronic Devices as well), the octal plug-in base has the same pin connections as the relays already sitting in this type of equipment. If you want to call this a retrofit, go right ahead. That's it there in the picture, in a revealing 1 5/16" x 1 5/16" x 2 1/16" plastic enclosure.

The first few thousand are now beginning to roll, and while we're not quite ready to talk delivery by the carload, anyone interested in trying out 46's in sample quantities will get to sit in the sales manager's padded office for 8½ glorious minutes.

**We decided not to overdo it and gave him a Rolls-Royce instead.*

Series 46 Relays and other selected Sigma products and personnel on display at booths 2628-2630, New York Coliseum, March 20 to 23. Come energize them.

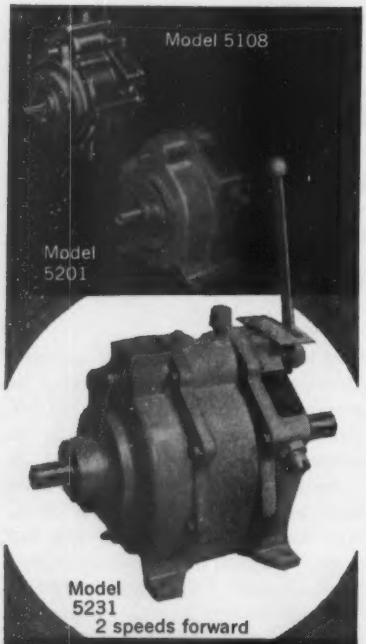
SIGMA

SIGMA INSTRUMENTS, INC.
89 Pearl Street, So. Braintree 85, Mass.

Circle 564 on Page 19

S-N REVERSING TRANSMISSIONS

5 models 8 and 28 h.p. with power packed versatility



S-N Reversing Transmissions are performance proven, space-saving single units which reverse under full load. Adaptable to the design or redesign of a wide variety of industrial equipment. For technical data write The Snow-Nabstedt Gear Corp., Hamden, Conn.

SPECIFICATIONS

Model No.		5231	5201	5108
Reduction Forward		1.97:1 3.34:1	3.16:1	3.75:1
Ratio Reverse		3.37:1	3.16:1	3.75:1
Power Up To		28 HP	28 HP	8 HP
Max. Input Torque in. lbs.		1000	1000	320
Max. Input Speed RPM		2400	2400	2400
Dimensions	Long	15 11/16"	11 1/2"	9 1/16"
	Wide	14"	13 1/2"	10"
	High	14 3/4"	14 1/4"	10 1/2"

SNOW-NABSTEDT
Industrial Division
Transmission Engineers
For Over Half a Century

Circle 566 on Page 19

Solodovnikov; translation edited by John B. Thomas and Lofti A. Zadeh; 307 pages, 5¼ by 8 in., paperbound; published by Dover Publications Inc., 180 Varick St., New York 14, N. Y.; $2.25 per copy.

This book was initially published in the Soviet Union in 1952 and constitutes one of the first comprehensive treatments of the subject.

Principles of analysis of linear systems, statistics of random signals, and theory of linear prediction and filtering are covered. Text does not include discussions of some of the specialized contributions to theory of filtering and prediction which have been made since 1952.

Government Publications

Handbook—Preferred Circuits, Navy Aeronautical Electronic Equipment, NAVWEPS 16-1-519, Supplement No. 3. *100 pages, 7¾ by 10¼ in., paperbound, stapled; available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.; $0.55 per copy.*

Aim of preferred-circuits program is voluntary reduction of unnecessary circuit variations in military equipment. This latest supplement to preferred-circuits handbook contains seven germanium-transistor circuits, two silicon-transistor circuits, and one vacuum-tube instrument-servo circuit.

The germanium-transistor circuits are a compatible set of transistor digital-logic circuits for use in computer, control, and communication equipment. One silicon-transistor circuit is a variable-gate generator and the other is a nonsaturating, bistable multivibrator operating at rates up to 1 mcps. Vacuum-tube circuit is a phase-sensitive null detector for use in servo-control circuits.

Precision Measurement and Calibration: Volume I—Electricity and Electronics, 845 *pages,* **$6.00** *per copy.* **Volume II—Heat and Mechanics, 965** *pages,* **$6.75** *per copy.* **Volume III—Optics, Metrology, and Radiation, 1025** *pages,* **$7.00** *per copy. Each volume is 9½ by 11½ in., clothbound; published by National Bureau of Standards, U. S. Dept. of Commerce, Washington 25, D. C.*

This three-volume set constitutes a reference handbook of the field of standards and is composed of previously published technical papers

TIPS AND TECHNIQUES

VOLUME II ENGINEERING AIDS

- **Simplifying Constructions**
- **Utilizing the Slide Rule**
- **Construction Aids**
- **Shortcuts for the Engineer**

Helpful Tips and Techniques that apply to engineering methods, are now available in this one-volume reference. This manual contains 32 pages of illustrated time-and-money saving procedures that every engineer can use.

$1.00 a copy

Order from

MACHINE DESIGN
Reader Service
Penton Building
Cleveland 13, Ohio

(Remittance or Company Purchase Order must be enclosed with order)

YOU CAN DESIGN-IN SPEED SELECTION

RELIANCE

at MINIMUM COST

Here is a simple low-cost drive package for speed adjustment or speed changes. For example: a 3 hp. drive* for less than $95.00!

The Reeves Vari-Speed Motor Pulley provides an infinite selection of output speeds within its range, by a turn of the wheel. This drive takes up little more space than a constant speed motor and sheave drive, and is just as easily designed into your machinery.

The Reeves Motor Pulley is compact, easy to maintain and economical. It uses a variable pitch pulley and sliding motor base to do the job of expensive gearing or complicated electrical devices, and the motor pulley gives good repeat accuracy on speed changes.

The condensed specification table below gives the standard outside limits of Reeves Vari-Speed Motor Pulley performance. For detailed data contact your nearest Reliance Representative or write for Catalog G-101.

*Consumer net price, including sliding motor base, Reeves variable pitch pulley and drive belt.

MOTOR PULLEY SELECTION

3 to 1 Speed Range (1800 rpm. motor)

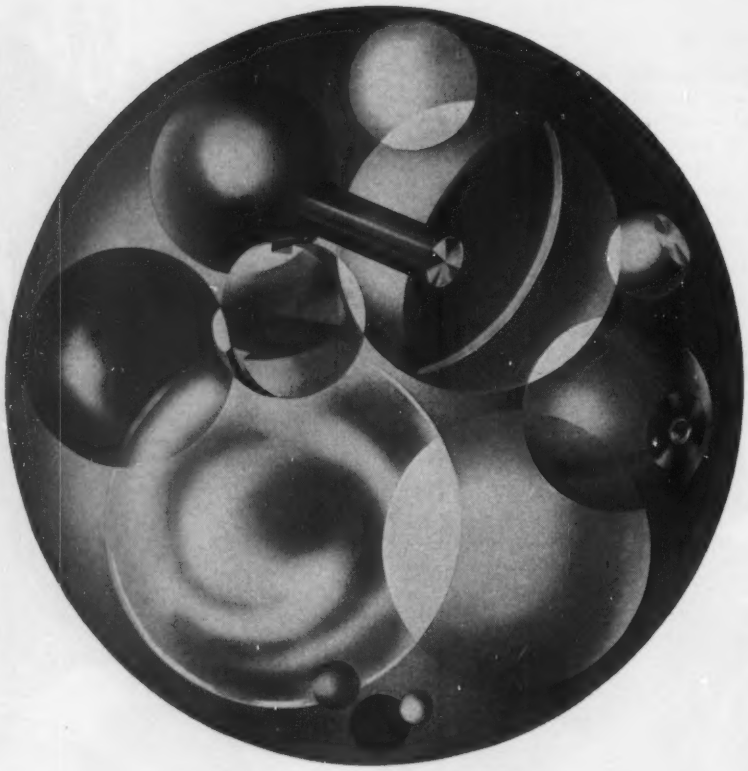
Horsepower (at maximum speed)	½	¾	1 or 1½	2	3	5	7½ or 10	15
Available Driven Output Speeds	1670 to 210 rpm	1515 to 200 rpm	1870 to 245 rpm	1545 to 195 rpm	1435 to 210 rpm	1560 to 225 rpm	1560 to 235 rpm	1065 to 375 rpm
Motor Pulley Diameter (minimum speed setting)	5½"	6"	7½"	8"	9½"	10"	12"	12"
Motor Pulley Size Number	95	96	97	98	99	910	912	912-15

For quick delivery see your local distributor—check the Yellow Pages, Power Transmission Section.

RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 283A CLEVELAND 17, OHIO • Canadian Division: Toronto, Ont.

G-1692



BALLS UNLIMITED

We make precision balls of ALL MATERIALS from plastics to carbides, including special alloys—ALL SIZES, standard and special, from .005" to 24" or larger—in experimental or mass-production quantities—to .000010" tolerance if desired, depending on size and material. *Many are available from stock.* • We also make balls with stems, flats, slots, grooves, tapped holes, counterbores, and other secondary operations—ball segments—hollow and plated balls. • What can we make for YOU?

BULLETIN BU-1 gives details; lists properties and uses of STOCK BALLS of 8 materials. Write for it!

iTi

INDUSTRIAL TECTONICS, INC.

manufacturers of precision balls and bearings

BALL DIVISION | 3686 JACKSON RD., ANN ARBOR 2, MICHIGAN

by the NBS staff. A complete index of the entire set by author, subject, and title is included in each volume.

Some specific topics discussed in volume I include suggested practices for electrical standardizing laboratories, establishment and maintenance of electrical units, national standards of time and frequency in the U. S., and testing of electrical instruments.

Specific topics discussed in volume II include precision resistance thermometry and fixed points, methods of testing thermocouples, humidity standards, and evaluation of resistance strain gages at elevated temperatures.

Specific topics discussed in volume III include units and systems of weights and measures, optical instruments, design and test of standards of mass, absorption of x-rays in air, and comparisons of national radium standards.

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 161740. On the Utilization of the Concept of Boundary Impedance in Vibrations of Bars. By F. J. Wilmers and R. F. Lambert, University of Minnesota; 39 pages, 8¼ by 10¾ in., paperbound, stapled; $1.25 per copy.

Techniques derived from electrical transmission-line theory are employed to measure boundary impedance. Concept is used to describe conditions at the extreme boundaries of a bar. Similarities and differences between mechanical and electrical transmission lines are discussed.

PB 161755. Damping of Rectangular Plate Vibrations. By T. S. Lundgren, C. C. Chang, and Y. C. Whang, University of Minnesota; 20 pages, 8¼ by 10¾ in., paperbound, stapled; $0.75 per copy.

Part A analyzes the effect of an impact-type damping mechanism on a vibrating square plate. Force exerted by damping mechanism on plate is idealized as a series of impulses acting at center of plate.

Part B analyzes effect of a damping device on vibrations of a rectangular plate. Damper is a free piston in a closed cylinder attached to center of plate.

PB 161813. Heat Resistant-Elastomeric Material Combinations and Forms. By R. E. Stapleton, J. Pappis, F. J. Hill, and T. M. Hinkes, Trionics Corp.; 39 pages, 8 by 10½ in., paperbound, side-stapled; $1.25 per copy.

New concepts for novel and unconventional material configurations and combinations having elastomeric characteristics from —70 F to 1000 F were investigated. Results showed that inorganic materials such as ceramics, glasses, and metals can be substituted for elastomeric materials if certain design and fabrication factors are considered.

PB 161828. The Explosive Working of Metals. By John Pearson, U. S. Naval Ordnance Test Station; 48 pages, 8 by 10½ in., paperbound, side-stapled; $1.50 per copy.

Current operations in explosive forging are related to fundamental aspects of forces, pressures, velocities, and other factors. Parts forming, sizing, shaping, cutting, compacting, welding, and other metalworking operations performed by energy release from a detonating or deflagrating explosive are evaluated.

PB 161972. Fuel Cell Systems. By John E. McCormick; 17 pages, 8 by 10½ in., paperbound, stapled; $0.50 per copy.

Thermodynamics of six different types of fuel cells are discussed: Liquid electrolyte, molten-salt electrolyte, consumable electrode, ion-exchange electrolyte, chemical regenerative, and thermal regenerative. Advantages and limitations of these cells are listed.

Said Isaac Newton:

"Every particle of matter attracts every other particle with a force directly proportional to the product of their masses and inversely proportional to the square of the distances between them."

Until recently, the thrust which propelled rocket vehicles into their coast stage, prior to orbiting, was provided by booster stages. The fuel carried by the satellite stage was used only to inject itself into orbit.

Now, however, a scientist at Lockheed Missiles and Space Division has evolved a Dual Burning Propulsion System which allows higher orbits and heavier payloads. With this system, the satellite vehicle fires immediately after the last booster stage burns out, thus augmenting the begin-coast speed. Later the satellite stage is re-started to provide orbit injection.

An even more recent development by Lockheed is a triple-burning satellite stage. This will permit a precise 24-hour equatorial orbit, even though the vehicle is launched a considerable distance from the equator.

These principles have made possible the early development of the MIDAS satellite. Moreover, they substantially increase the altitude and payload of the DISCOVERER series. Lockheed, Systems Manager for these programs and for the POLARIS FBM, is pursuing even more advanced research and development projects. As a result, there are ever-widening opportunities for creative engineers and scientists in their chosen fields.

Why not investigate future possibilities at Lockheed? Write Research and Development Staff, Dept. M-15C, 962 West El Camino Real, Sunnyvale, Calif. U.S. citizenship or existing Department of Defense industrial security clearance required.

Lockheed / **MISSILES AND SPACE DIVISION**

Systems Manager for the Navy POLARIS FBM and the Air Force AGENA Satellite in the DISCOVERER and MIDAS Programs

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA • CAPE CANAVERAL, FLORIDA • HAWAII

Is This Job for You?

BACKGROUND—Recent degree in mechanical or electrical engineering. About three years of design-engineering experience.

ABILITIES—Able to evaluate technical information on design techniques, new machines, components. Provable ability to write clearly and accurately. Should work well with people, have initiative and imagination, demonstrate creative as well as practical ability.

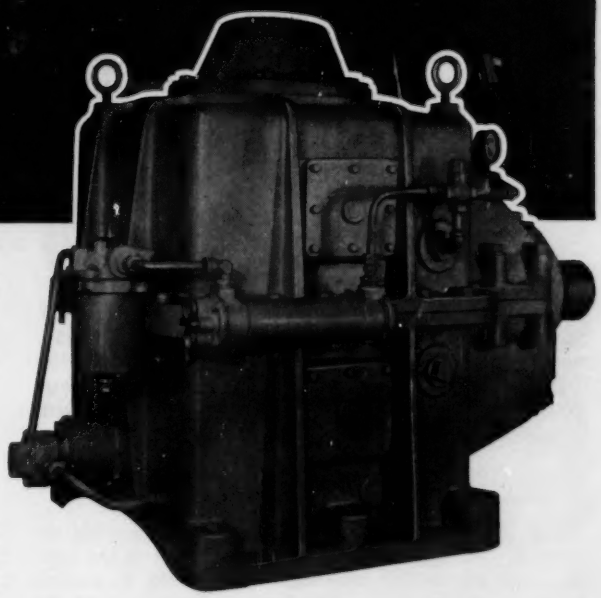
ENVIRONMENT—Cleveland, Ohio, with some out-of-town travel. As assistant editor on MD's staff of 21 engineer-editors. In Penton Publishing Company, a growth company, with 5 magazines and some 60 editors.

COMPENSATIONS—Salary comparable to that in industry. Chance to grow within the company. Unusual opportunity to broaden education, experience, and contacts. Stimulating work.

* * *

If this appeals to you not merely as a job but as the basis of a career, write at once (with all pertinent facts) to the Editor, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

PHILADELPHIA REDUCERS
keep disaster from Hartford



Five miles of dikes protect Hartford, Connecticut against river heights of 45 ft. Yet excess drainage into low lying industrial areas starts at 8-foot levels. Result: pumps operate almost continuously . . . 7 days a week! Seven flood control pumps for Hartford . . . totalling 224,000 gpm . . . are all driven through 450 hp, 1200 rpm Philadelphia Spiral Bevel Reducers.

There are three good reasons why Philadelphia Spiral Bevel Reducers give extra reliability on any continuous, heavy duty job.

1. Spiral bevel gearing is heat treated and hardened after it is cut . . . then lapped to a mirror finish for perfect tooth contact.
2. Heavy-duty bearings and generous bearing spans provide extra rigid mounting and keep bearing loads low.
3. Force feed lubrication. Generous oil reservoir and large radiation surfaces mean cooler running units.

Catalog SB-60 describes our complete line. Write for your copy today.

Philadelphia Spiral Bevel Reducers offer dependable performance with high efficiencies. Housings are fully enclosed, compact and self contained with freedom from oil leakage. Note easy accessibility of oil pump, filter, and cooler.

philadelphia gear drives

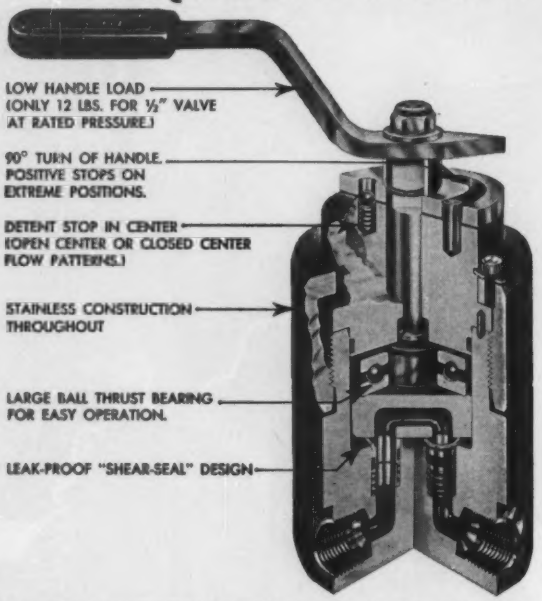
PHILADELPHIA GEAR CORPORATION

King of Prussia (Suburban Philadelphia), Pennsylvania

10,000 P.S.I.

4 WAY VALVE

FOR LIQUIDS OR GASES


LOW HANDLE LOAD (ONLY 12 LBS. FOR ½" VALVE AT RATED PRESSURE.)
90° TURN OF HANDLE. POSITIVE STOPS ON EXTREME POSITIONS.
DETENT STOP IN CENTER (OPEN CENTER OR CLOSED CENTER FLOW PATTERNS.)
STAINLESS CONSTRUCTION THROUGHOUT
LARGE BALL THRUST BEARING FOR EASY OPERATION.
LEAK-PROOF "SHEAR-SEAL" DESIGN

This new four-way valve series comes in pipe sizes from ¼ to 1 inch, but may be obtained with tube, AND 10050, or any preferred special high pressure connection. It will withstand surges of up to 15,000 P.S.I. without damage to the valve's sealing qualities. It is designed for a burst pressure of 30,000 P.S.I.

No port to port leakage occurs in the detented positions because of the exclusive "Shear-Seal" design.

Long, maintenance-free service is assured because the optically flat metal to metal sealing surfaces of the sealing rings and mating rotor faces are protected by staying in constant intimate contact; flow is always through the center of the "Shear-Seal", never across sealing surfaces (as in conventional valve design). Sealing qualities actually improve as the self aligning "Shear-Seals" lap themselves to a more perfect fit with each valve operation.

Of course, there is no external shaft leakage, because the pressure is confined to the flow passages.

Write for Catalog 59-60

CONTROL VALVE DIVISION **barksdale valves**

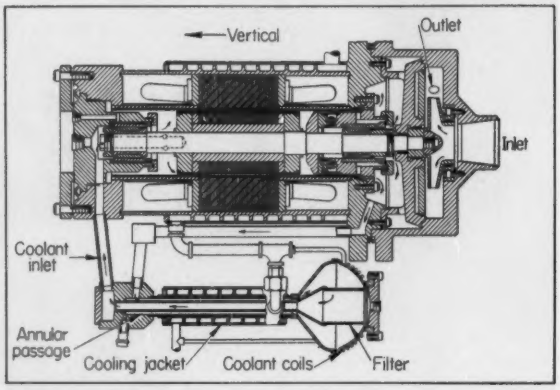
5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

NOTEWORTHY

Patents

Regenerative Cooling System

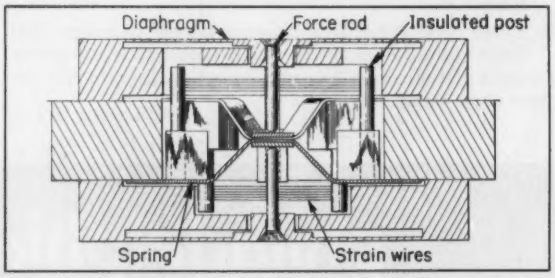
A regenerative cold trap combines a cooler and a reheater in one compact unit and insures that impurities in the coolant do not clog the coolant passages. Coolant enters the motor-pump through the inlet tube and circulates through the pump coolant passages. The warm fluid then passes into the cold trap, through the filter, and back to the inlet tube. Heat transfer



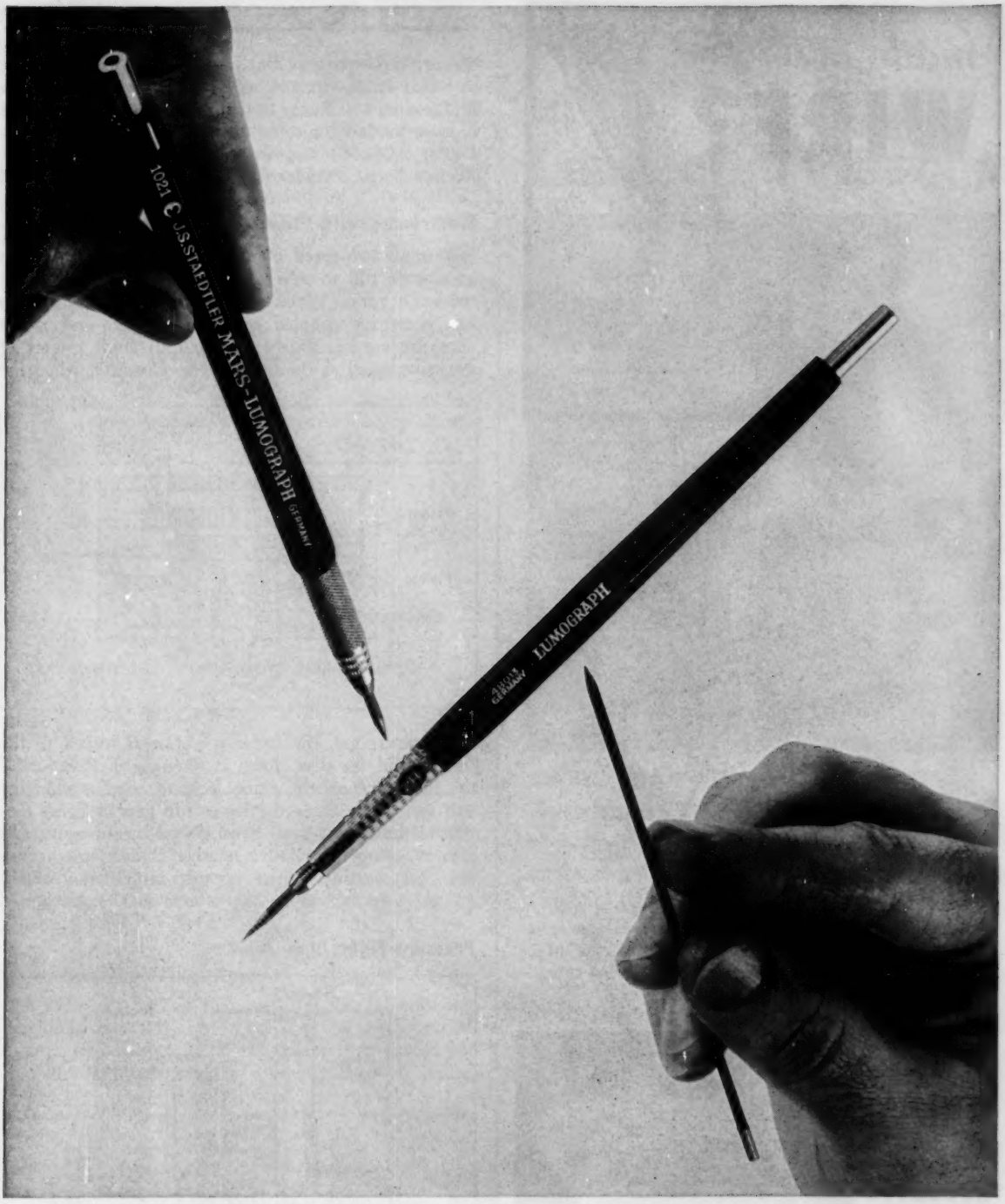
from the warm fluid in the annular coolant passage to the cool fluid from the cooling chamber insures that the lowest temperature in the system is at the base of the cold trap. Thus, any precipitation will occur at this point, and coolant passages and bearing surfaces are kept free from impurities. *Patent 2,964,659 assigned to Westinghouse Electric Corp., East Pittsburgh, Pa., by Oliver P. Steele III and Harold F. Kongabel.*

Quick-Response Differential-Pressure Transducer

A sealed differential-pressure transducer uses separate diaphragms to provide accurate measurement of rapidly fluctuating pressures. In addition, since system fluids do



not enter the transducer housing, the unit can be used with corrosive fluids. Displacement of the diaphragms is transmitted to force rods acting against a steel pad fastened to flat springs. Insulated posts, mounted on the



LATEST WORD FROM MARS is the superb new Technico lead holder—with clear-view degree indicator placed right at your fingertips. Contoured for perfect balance, with new positive finger grip, it's the newest of many fine MARS drafting aids—all designed to make your work easier, and to make it look better and reproduce better.

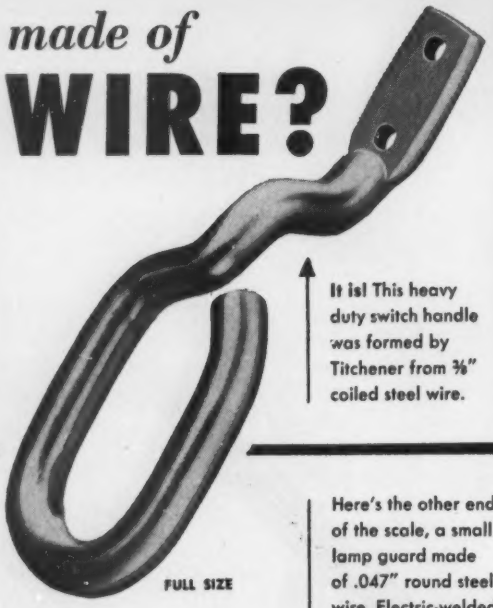
Among the famous imported Mars drafting products are: the Mars-Technico push-button lead holders (with adjustable degree indicator*, with specific degree imprint, the economy model*); Mars-Lumograph drawing leads*, 18 degrees, EXB to 9H; Mars-Lumograph drawing pencils, 19 degrees, EXEXB to 9H; Mars-Duralar pencils and leads for drafting on Mylar® -base drafting film —5 special degrees, K1 to K5; Mars-Duralar Technicos with adjustable Duralar degree indicator; Mars-Lumochrom colored drawing pencils, 24 shades. Also: Mars Pocket-Technico for field use; Mars pencil and lead sharpeners; Mars Non-Print pencils and leads; Mars-Duralar erasers. Mars products are available at better engineering and drafting material suppliers everywhere.

®T.M. for duPONT's Polyester film. *Shown.

the pencil that's as good as it looks **MARS**

J.S. STAEDTLER, INC.
HACKENSACK, NEW JERSEY

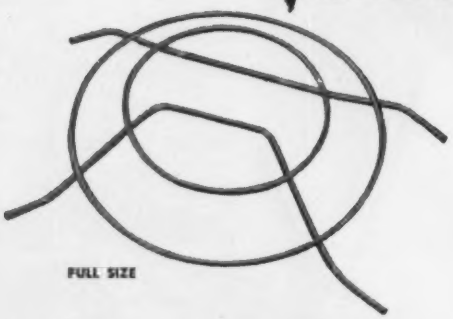
made of
WIRE?



It is! This heavy duty switch handle was formed by Titchener from ⅜" coiled steel wire.

FULL SIZE

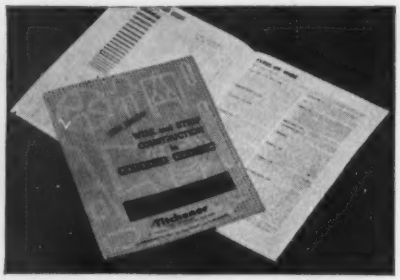
Here's the other end of the scale, a small lamp guard made of .047" round steel wire. Electric-welded construction — two rings and two legs.



FULL SIZE

Our facilities for automatically forming wire components and welding wire assemblies can solve problems, save money. All sizes of wire from ⅜" to .047"— many metals, finishes, too. Engineering consultation is available for the asking.

FREE *design handbook*



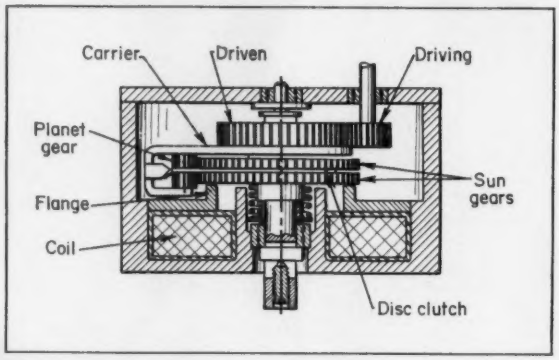
Write for your copy today!

E. H. Titchener
AND COMPANY
65 CLINTON STREET, BINGHAMTON, NEW YORK

spring arms, transmit diaphragm movement to a series of bifilar strain-sensitive wires, which form a four-arm bridge circuit. Change in wire resistance due to changes in wire tension indicates the value of force variations. *Patent* 2,969,514 *assigned to Consolidated Electrodynamics Corp., Pasadena, Calif., by Gerald R. Curtis.*

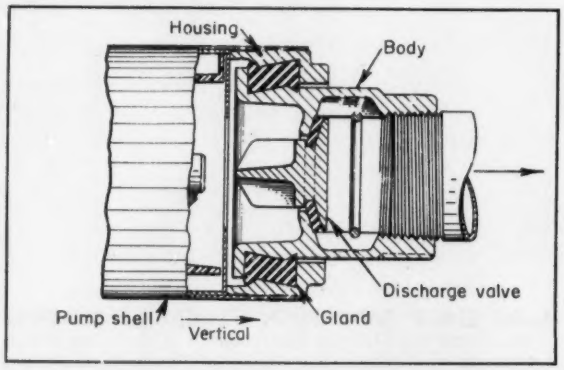
Electromagnetic Planetary Transmission

A small two-speed planetary-gear transmission uses an electric coil to select either direct drive or a high-reduction ratio. When the coil is de-energized, two sun gears are coupled by a disc clutch and rotate with the carrier, so that the output shaft rotates at the same speed as the driven gear. However, when the



coil is energized, the lower sun gear is locked to the flange, and the disc clutch is disengaged. Rotation of the carrier causes the planet gear to move around the two sun gears. Since the lower sun gear is fixed, motion of the output shaft is controlled by the upper sun gear. Varying the relative number of teeth in the sun gears provides any desired reduction ratio. *Patent* 2,966,-809 *assigned to Lear Inc. by Walter F. Derylo.*

Pressure-Tight Pipe Joint

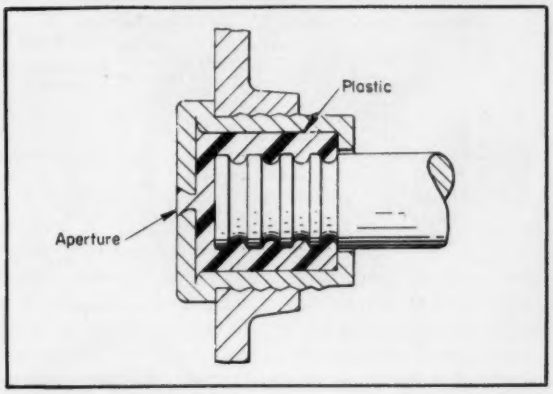


Three-piece pipe coupling assembly is held in place by pump weight and discharge pressure. The housing, threaded for attachment to the pump shell, has an annular seat facing the pump. The discharge body, telescoped with the housing, has a flange providing an annular seat on its upper surface. The gland is dimensioned for a slip fit within the cavity provided.

The weight of the pump plus its discharge pressure cause the housing to move downward with respect to the body. This action is translated to the gland as a compressive force, to form an effective seal. The elastomeric gland forms the only mechanical connection between housing and body, thereby insulating vibration. The gland is nonconductive. *Patent* 2,962,-304 *assigned to The Tait Manufacturing Co., Dayton, Ohio, by Kenneth R. Lung.*

Molded-In-Place Plastic Bearing

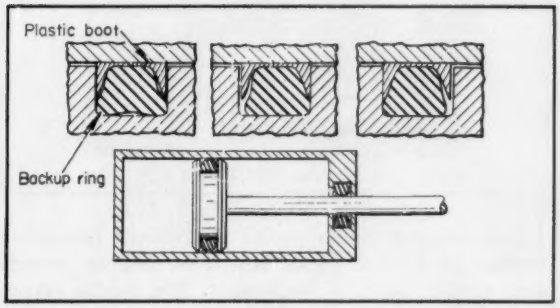
A molded bearing of plastic is injected under pressure within a housing enclosing a member so that the plastic conforms to the member and hardens to form a supporting backing and a bearing surface. Apertures to receive the plastic are located in the bearing housing



according to bearing type. The techniques can be adapted for several bearing forms: Ball and socket, straight journal, annular groove, and spline. *Patent* 2,970,869 *assigned to American Metal Products Co., Detroit, Mich., by Paul P. Thomas.*

Wear-Resistant Fluid Seal

A fluid-seal backup ring, with trapezoidal cross section, rides in a Teflon boot, reducing failures by rubber flow and scrubbing. The trapezoidal cross section and the extended tapered margins prevent material separa-



tion during reciprocating movement by limiting flow and scrubbing to the lobe of the base section. During shifts in the direction of pressure, the sealing ring moves

NEW Grades in Laminated Plastics

An Example of
Synthane *You-shaped* Versatility

There are 7 new much-wanted grades of Synthane laminated plastics. Four are flame-retardant—Grades FR-1, FR-2, FR-3, and FR-4. Three are the new high-temperature grades G-3HT, ARF-HT and AA-HT.

These grades add versatility to the variety of Synthane grades offered for your convenience and from which you may now choose with the same confidence you have always had in Synthane as a source of supply.

You-shaped Versatility makes Synthane a Better Buy in Laminates.

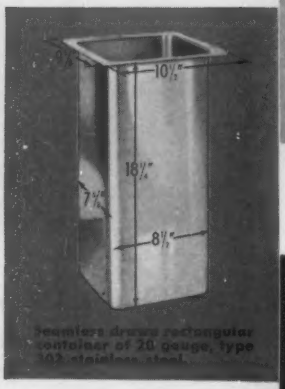
SYNTHANE CORPORATION OAKS, PENNA.

Synthane Corporation, 5 River Rd., Oaks, Pa.
Gentlemen:
Please send me your Engineering Bulletins on:
☐ New Flame-retardant Grades ☐ New High-temperature Grades
Name_____
Address_____
City_____ Zone____ State_____

Circle 575 on Page 19

No Tooling Cost
To Draw Shapes
Like These
and dozens of others
with POLAR WARE
Facilities

Seamless drawn cylindrical container of 22 gauge steel.



Seamless drawn rectangular container of 20 gauge, type 302 stainless steel.

Seamless drawn oval container of 20 gauge, type 302 stainless steel.

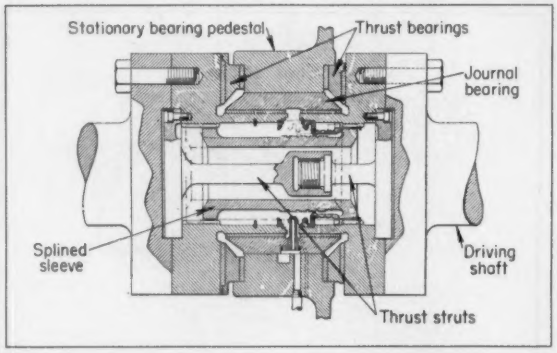
■ It will pay you to check out your new design ideas with Polar Ware. The chances are good that our hundreds of existing dies, plus the facilities of our complete tool and die shop, can save you thousands of dollars in tool cost, plus weeks of waiting time. Difficult seamless deep drawing work in stainless steel is our specialty, in gauges from 3 to 30; also carbon steel and aluminum. Take advantage of our more than 50 years' experience in metalworking. Without obligation, send your inquiry to the Contract Department.

Polar Ware Co.
4500 Lake Shore Road—Sheboygan, Wisconsin

only a short distance before the lobe comes into contact with the boot. Thus, rubber flow is reduced to a minimum. Since the boot is Teflon, scrubbing between the ring and boot is insignificant. The special shape of the sealing ring also provides more sealing surface than a conventional O-ring. *Patent* 2,968,501 *assigned to A-P-D Co., Minneapolis, Minn., by Richard E. Tisch.*

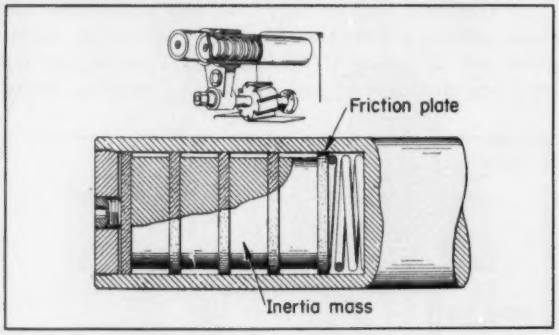
Thrust-Absorbing Flexible Shaft Coupling

A compact splined flexible coupling has built-in thrust and journal bearings, and uses a lubricating assembly that guards against the entry of foreign matter into the bearings and splines. The splines are machined with enough radial clearance so that some angular misalignment can be tolerated. Thrust loads are absorbed by a pair of struts, which also can flex



to absorb misalignment. A stationary bearing pedestal carries a journal bearing and a pair of thrust bearings and is the main load-carrying member. Oil fed into the bearing pedestal is filtered by centrifugal action, all foreign matter being collected in sludge chambers and ejected. *Patent* 2,964,929 *assigned to General Electric Co. by Herbert N. Hoffman.*

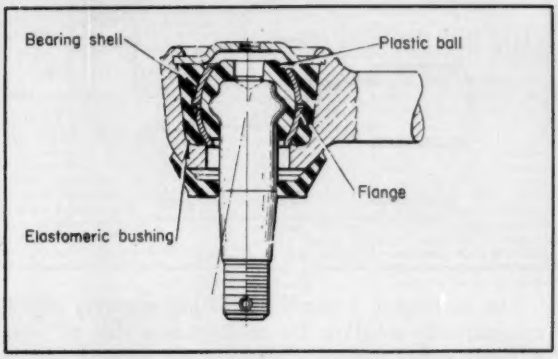
Frictional Vibration Damper



A number of inertia masses interspersed between a number of friction plates dissipates vibratory energy over a wide range of frequencies. The inertia masses and friction plates are housed within the member that is to be stabilized and are spring loaded into a predetermined degree of frictional engagement. The masses lag behind the motion of the friction plates in an out-

of-phase relationship when the housing member is oscillated in a direction transverse to its axis. The friction created by the relative movement between the two elements serves to dissipate the vibratory energy of the member in the form of heat. The device is applicable to machines incorporating extended overarms. *Patent 2,960,189 assigned to Kearney & Trecker Corp., West Allis, Wis., by John G. Osburn.*

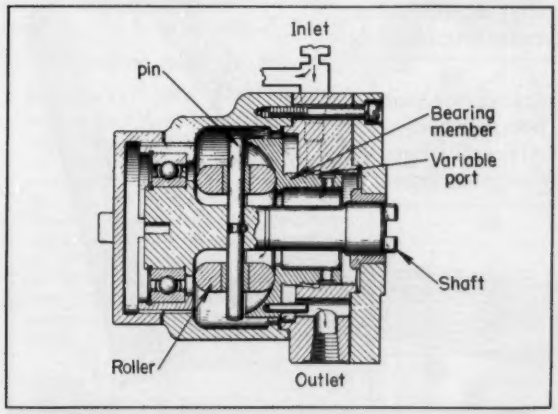
Pre-Positioned Ball Joint



A resiliently mounted ball-joint assembly is constructed so that the longitudinal axis of the stud assumes a predetermined angular position relative to the lateral plane of the socket. When an angular force is applied to tilt the stud, one of the bearing half-shells is moved in one lateral direction and the other bearing half-shell is moved in the opposite lateral direction against the elastic resistance of an elastomeric bushing. *Patent 2,970,853 assigned to General Motors Corp., Detroit, Mich., by Max P. Baker.*

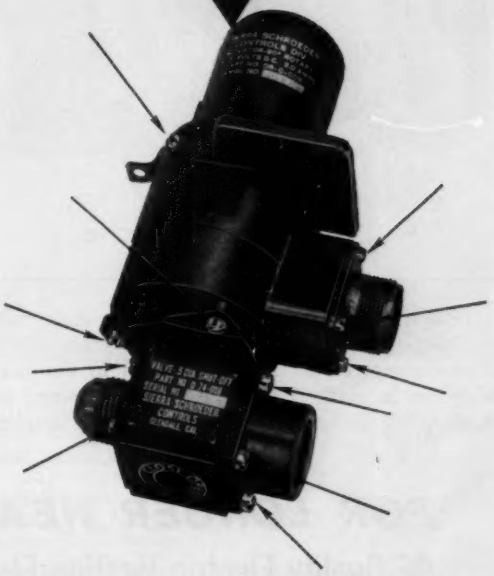
Springless Fluid Governor

A pair of rollers positioned radially by centrifugal force regulate a springless governor which is extremely sensitive to speed changes. Pressure to the device being governed is controlled by the size of the variable con-



trol port, which determines the amount of system oil that is bypassed to the reservoir. Rollers are mounted on a pin fastened to a rotating shaft. As speed in-

LONG-LOK®



Use of Long-Lok Self-Locking Screws on this Sierra-Schroeder Controls Model 74-01B Valve eliminated lock wire, provided repeated re-use — simplified field service. Long-Lok Self-Locking Screws are used on the housing of this valve as well as on the gear train mounting where an extremely restricted assembly area makes the use of lock wire a time consuming and prohibitively expensive operation.

Long-Lok Self-Locking Screws can speed and improve your assembly operations — provide important savings in time and labor — assure highest reliability.

Available in all head sizes and styles — have wide temperature range — qualified to MIL-F 18240 specifications — head marked for self-lock identification.

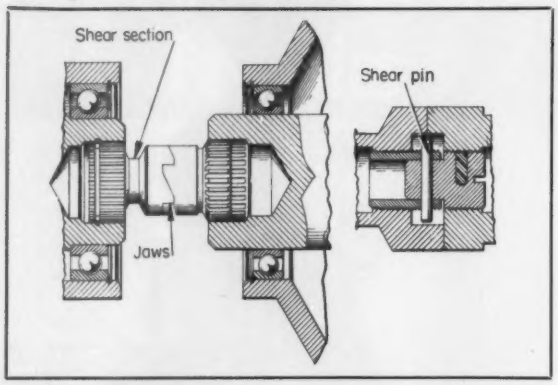
If you have a fastener problem, Long-Lok can help you.

WRITE FOR CATALOG LL-61

Circle 577 on Page 19

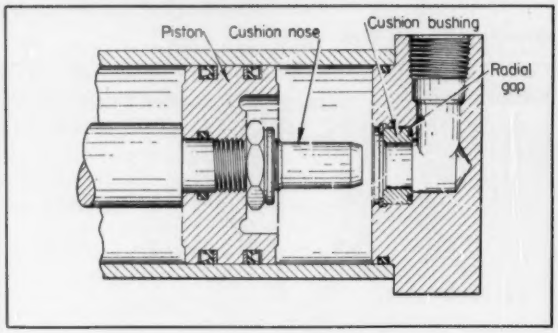
creases, centrifugal force moves the rollers along the pin, moving the bearing element right and decreasing the port opening. Oil pressure acting in the opposite direction on the bearing element tends to increase the port opening until a balance point is reached for the speed of shaft rotation. *Patent* 2,962,037 *assigned to International Harvester Co. by John P. Simon.*

Rotary-Shaft Safety Coupling



Two shear-points are provided in a shaft coupling to guard against overload damage of either driving or driven components. A shear section in the coupling body can be made to fail at any predetermined torque. A shear pin locks the two sections of the coupling together and is designed to fail under excessive axial loads. If the driven shaft should suddenly apply torque to the driving shaft—due, for example, to the failure of an overrunning clutch—the design of the coupling jaws would tend to separate the two sections of the coupling, shearing the locking pin and disconnecting the shafts. *Patent* 2,964,931 *assigned to The Garrett Corp., Los Angeles, by Kal K. Sorenson.*

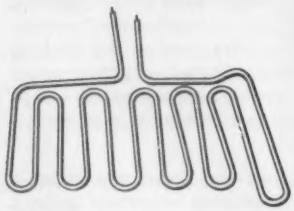
Self-aligning Piston Cushion



The bushing in a piston-cushioning assembly adjusts automatically to allow for misalignment due to wear. A small radial clearance between the bushing and its housing allows the bushing to shift into line with the cushion nose. The chamfer at the end of the cushion nose assures smooth action between the nose and bushing. *Patent* 2,960,068 *assigned to Logansport Machine Co. Inc., by Robert E. Becker.*

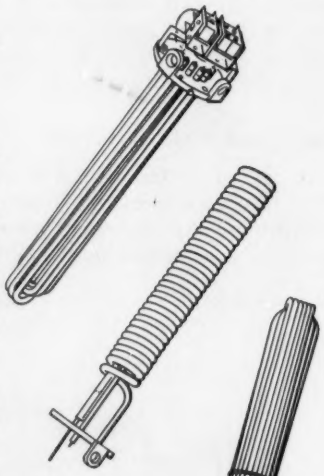
FOR LONGER HEATER LIFE . . .

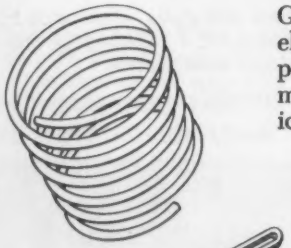
GF Quality Electric Heating Elements!

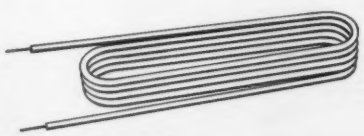


For high quality tubular heating elements, designed and built to exacting specifications, check the GF line. Available in steel, stainless, copper, inconel, incaloy . . . in diameters as specified up to and including .750" . . . with wide variety of flanges and heads designed to ASA Standards or customer specification. Many types of integral thermostatic controls offered.

GF designs and manufactures superior heating elements and devices. If not satisfied with present heater life, contact GF now! Recommendations and preliminary engineering service without obligation.



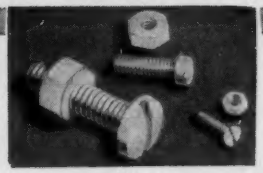




GENERAL FITTINGS COMPANY

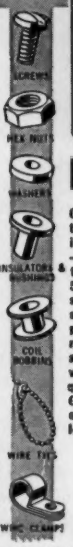
EAST GREENWICH • RHODE ISLAND

NEW NYLON & THERMO-PLASTIC parts from GRC



Economically mass produced on fully automatic patented machines, GRC nylon parts are available from stock in many sizes and types. GRC uses single cavity techniques, molds in one automatic cycle, gets accurate, uniform parts.

These advantages, these economies, apply too, to tiny made-to-order parts to your specifications . . . in quantities of 25,000 to many millions. Write for bulletin describing GRC's unique method for injection molding small plastic parts or send prints for quotations. Ask about our zinc alloy die castings too!



NYLON SCREWS AND NUTS

GRC's complete line of high quality, close tolerance molded nylon screws and hex nuts include screws in standard commercial heads —Phillips or slotted types—in sizes from #4 thru ¼"; hex nuts in ten sizes (#2 thru 5/16") GRC molded nylon miniature machine screws—half the weight of aluminum—in sizes as small as #0—make more compact designs possible. GRC's single cavity molding technique adds exceptional uniformity, accuracy, economy to nylon's high strength-to-weight ratio, built-in electrical insulating qualities, stability, resilience and elasticity. GRC's molded fasteners are available in Nylon or Delrin in a wide range of types, sizes and lengths.

NO SIZE TOO SMALL
Maximum: 1¼" long —.03 oz.

Write for samples, prices and GRC's New Detailed Industrial Fastener Catalog.

GRIES

GRIES REPRODUCER CORP.
World's Foremost Producer of Small Die Castings
32 Second St., New Rochelle, N. Y. • NEw Rochelle 3-8600
See us at the IRE — Booth #4030

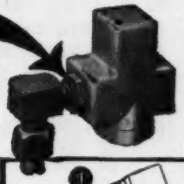
Circle 579 on Page 19

TRU-SEAL

TEFLON SEAL

PAT. PENDING

Saves hours in piping installations

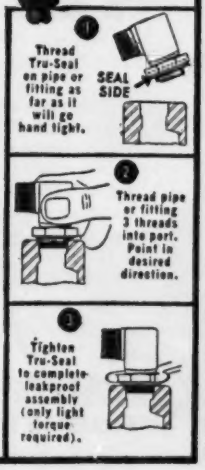


Eliminates leaks in oil, air, water, vacuum, chemical lines

Tru-Seal saves hours in assembling piping installations because it enables you to run your pipe lines in any direction you wish, quickly and easily—without having to recut and re-thread piping sections. Wherever used on air, oil, water, steam, vacuum or chemical lines, it seals perfectly at —100° F. to plus 500° F.—*without the use of pipe dope.* Its installation requires only light tightening torque, thus eliminating over-tightening damage to valves, pumps, compressors, and other fittings.

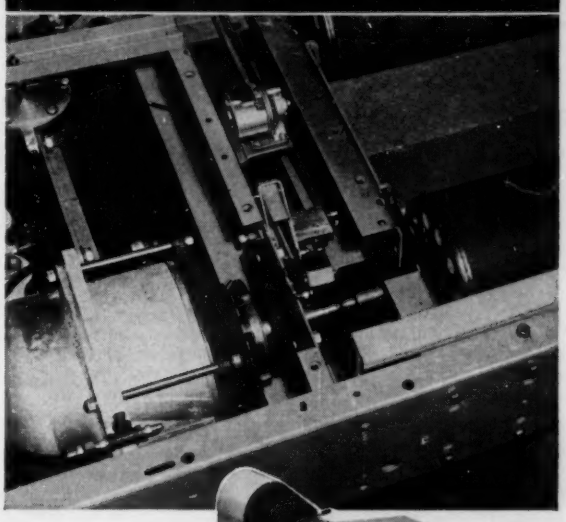
For further information write

TRU-SEAL DIVISION
FLICK-REEDY CORPORATION
7NO16 York Rd., Bensenville, Ill.
"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.


1
Thread Tru-Seal on pipe or fitting as far as it will go hand tight.
SEAL SIDE
2
Thread pipe or fitting 3 threads into port. Point in desired direction.
3
Tighten Tru-Seal to complete leakproof assembly (only light torque required).

Circle 580 on Page 19

Sier-Bath Couplings Help Clayton "BUILD ROADS IN MINUTES"



Clayton dynamometers, "the world's most widely used", can simulate any road condition in a matter of minutes and completely road test your car without leaving the corner garage.

Standard Sier-Bath flexible couplings are specified on every chassis model dynamometer made by the Clayton Manufacturing Company of El Monte, Calif. and Cincinnati, Ohio. Their complete line of "Turbo-Closed System" dynamometers are world famous for controllability, smoothness of operation and long service life.

Clayton needed a strong coupling to take the stop-start-and reversing torques inherent to this application, but the coupling had to be small and compact due to space limitations.

Sier-Bath's unique one-piece sleeve design provides the strength Clayton requires and it also eliminates the extra bulk and weight associated with split-sleeve coupling designs which must be bolted together.

These product advantages will add to your next design when you specify Sier-Bath flexible couplings.

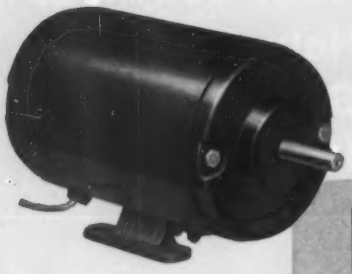
Get complete engineering information on both standard and special Sier-Bath flexible couplings . . .

Send For Your Catalog Today.

Sier-Bath
GEAR AND PUMP CO., INC.
FLEXIBLE COUPLING DIVISION
9254 HUDSON BLVD., NORTH BERGEN, N. J.
Member A.G.M.A. Founded 1905

Circle 581 on Page 19

FHP motors... engineered especially for your product



The new RAE M-40 Series, in 3 ratings at 5000 RPM. AC/DC Universal or DC Shunt. M-41 and M-42 rated ½ H.P. M-43 and M-44 rated ¾ H.P. M-45 and M-46 rated 1 H.P. Available with any of Rae's gear units.

RAE motors

RAE engineers are recognized specialists in solving difficult FHP motor applications. By careful analysis and testing of your product, they can save you time and money in selecting the right motor.

RAE offers outstanding service and quality in a large variety of motors. Available in voltages up to 250, and up to 1/2 H.P. (higher for intermittent duty) with many gearhead motor combinations.

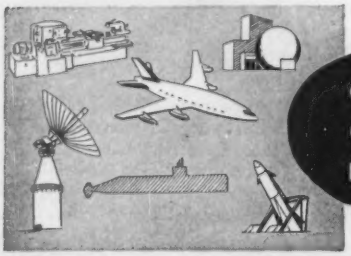
Find out how RAE motors can *improve your product* and *reduce costs* as they are doing for other leading manufacturers.

*Send for the "RAE" Engineering Data Sheet. It will help you supply the data necessary for recommendations and prices.

Rae MOTOR CORP.
2009 Kewaunee Street
Racine, Wisconsin

AC/DC Universal • DC Shunt Wound • DC Series Wound • Gear Reduction Motors • Governor Controlled Motors • Motors for Rheostat Control • Motors for Electronic Control • Permanent Magnet Motors and Gearmotors.

Circle 582 on Page 19

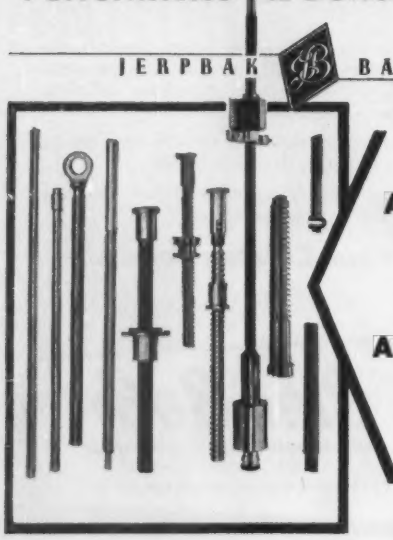


ON LAND
ON SEA
IN SPACE

Performance is Better with

JERPBAK BAYLESS

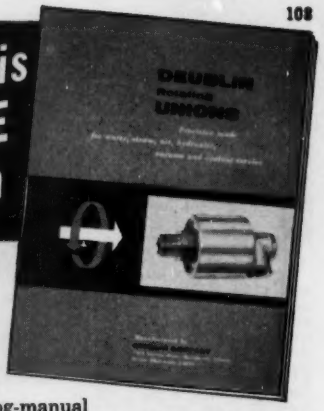
34150 Solon Rd.
Cleveland 39, Ohio



ACTUATOR SCREW and NUT ASSEMBLIES

Write For Literature

Send For This NEW FREE Catalog On



DEUBLIN Rotating UNIONS

A completely new, 20 page illustrated catalog-manual showing all the models of Deublin Rotating Unions for water, steam, air, hydraulic, vacuum and coolant service for the machines you make or use, is just off the press to help you get trouble-free service and reduce your "down-time" and keep maintenance to a minimum. Shown are rotating joints for water and steam service; monoflow and duoflow unions; single and double passage rotating air unions; hi-pressure lo-torque unions; extra capacity air unions; rotating siphon pipe unions; in-the-shaft mounted unions; hydraulic rotating unions and hi-speed coolant unions. Complete with full engineering data, cut-away drawings, plus instructions for installing, lubricating and servicing Deublin unions.

Write for your free copy today.

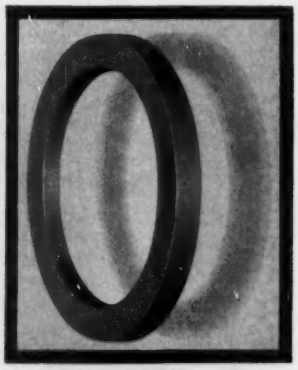
DEUBLIN COMPANY
1923 STANLEY ST. • NORTHBROOK, ILL.

Circle 583 on Page 19

get the **Goshen Rubber...**

IDEA*

*to precisely fabricate parts, seals, and components from selected compounds, and for specific applications only!

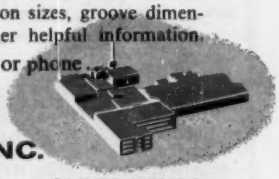


IN **TETRASEALS**

If you use O-rings, then you'll want to consider TETRASEALS for direct O-ring substitution, size for size, from 3/16" up to 15" ID. These *rectangular* section rings can save you money and render outstanding sealing performance in most static and some moving applications. Tetraseals use the same groove as standard O-rings, require no special tooling, and are one-piece (non-laminated). And they're available only from GRC . . . in natural, synthetic and silicone rubber compounds to meet MIL, AMS, SAE, ASTM and industrial specifications.

Ask for 12-page brochure on sizes, groove dimensions, compounds and other helpful information.

Write, wire or phone . . .



Goshen RUBBER CO., INC.

1731 S. TENTH ST. • GOSHEN, INDIANA
Phone KEystone 3-1111 TWX: GOSH 8701

Circle 584 on Page 19

Circle 585 on Page 19

DO YOU NEED
a low-cost source of metal fabricating?

Three large, well equipped plants at **Aurora, Ill., York, Pa.** and **Los Angeles** geared to economical production. Experienced in handling thousands of special items . . . products, parts, sub-assemblies, merchandising units, made to your specifications.

LYON Craftsmen in SHEET METAL PRODUCTION

LYON METAL PRODUCTS, INCORPORATED

Modern equipment includes coil steel slitting, leveling and edging, press work, all types of welding, electrostatic finishing. Sound design and engineering counsel.

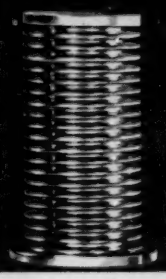
Send for 16-Page Booklet
It tells All!

LYON METAL PRODUCTS, INC.
General Offices, 381 Monroe Avenue, Aurora, Illinois

Circle 586 on Page 19

custom designed

MINIATURE METAL BELLOWS



DIAMETERS from 0.125"...
WALL THINNESS to .0008"

Servometer's nickel alloy bellows, designed to your requirements, range from 1" to 0.125" diameter, in any wall thinness down to .0008". Flexibility is 5 to 25 times greater than bellows limited to .003" thickness. Superior spring properties, high tensile strength, low hysteresis. Cylindrical, conical, dough-nut, kidney, capsule, and other shapes. No tooling charges on bellows. Delivery usually within 30 days.

Applications include hermetic rotary seals, liquid expansion absorbers, pressure transducers, flexible couplings, aneroids, springs, and assemblies. Write or telephone for technical assistance, data, free sample. Other sizes on request.

SERVOMETER CORPORATION
224 Main Ave., Passaic, N. J. PRescott 3-0474

Circle 587 on Page 19

THE AMPLEXOLOGIST

powders a price tag

Originally, the part shown (double V pulley) was designed to be machined from steel. But before it was incorporated into a new model the Amplexologist was called in. Result: the part was designed for powder metal and is now produced as a finished precision part which requires no machining. Estimated saving 82%. Sound interesting? Call the Amplexologist!

AMPLEX
DIVISION CHRYSLER CORPORATION DETROIT 31, MICHIGAN
OILITE

SEND FOR THE SECRET OF THE AMPLEXOLOGIST'S SUCCESS

1 ENGINEERING MANUAL
45 pages of technical information: How to determine correct applications for powder metal parts, bearings, filters.

2 NEW BEARING STOCK LIST
20 pages. 1066 standard sizes of Oilite self-lubricating bearings—bearing material. Selection guide, engineering data.

Circle 588 on Page 19

COMFORTABLE, UPHOLSTERED, ADJUSTABLE DRAFTING CHAIRS

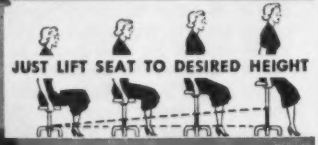
- 2 inch upholstered seat
- Full swivel seat
- 2-way adjustable backrest
- No soiled hands when adjusting seat
- Three sizes: 20" to 28"—24" to 32"—28" to 36"
- Gray, green, beige or brown finish

Also available with round metal or wood seat; or formed plywood or solid hardwood saddle seat.

FREE TRIAL

Use an AJUSTRITE chair or stool for 30 days without obligation. Prove to yourself the many advantages AJUSTRITE offers in comfort, utility and economy. Write today—we'll do the rest.

10 YEAR GUARANTEE



22 Models for Factories • Schools • Laboratories • Hospitals • Offices

AJUSTRITE CHAIRS AND STOOLS

AJUSTO EQUIPMENT CO.
Bowling Green, Ohio

Circle 589 on Page 19

Simplify design, purchasing, production with

MOORE PDQ* SET SCREWS

***PDQ** means price, delivery, quality. And you get all three with Moore Set Screws. The PRICE is right. Ample production capacity and inventories assure fast DELIVERY. And rigid control standards guarantee there's no skimping on QUALITY. Specify Moore Set Screws and *be sure.* Dependable quality for over 80 years.

Send for catalog

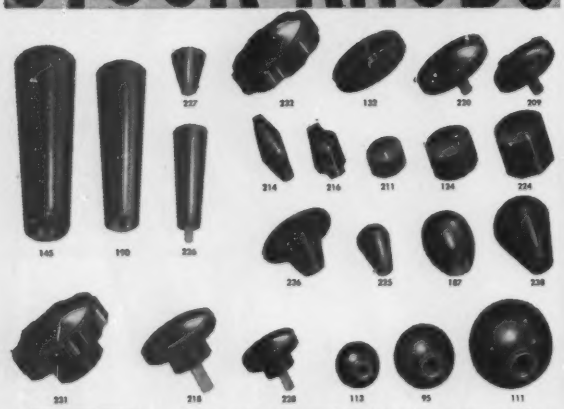
MOORE SET SCREWS

George W. Moore, Inc.
since 1880
93 Beaver St., Waltham 54, Mass.

Circle 590 on Page 19

STOCK KNOBS

...NO TOOLING CHARGE!



Wide selection molded plastic knobs, handles, hand-wheels at no tooling charge! Minor changes (inserts, threads, color, etc.) to suit requirements. Other modifications give your part a look of exclusive design at fraction of new mold cost! Write for complete illustrated catalog, or see Sweet's Product Design Catalog File.

DIMCO-GRAY COMPANY
204 EAST SIXTH STREET • DAYTON 2, OHIO

Circle 591 on Page 19

GOLD SICON withstands 500°F.

Gold SICON protects the grill and grill pouch of this attractive Quaker space heater under temperatures of over 500°F., without peeling, flaking, powdering or discoloring. *And it will retain its bright appearance indefinitely!* Do as Heil-Quaker did. Test SICON . . . up to 1000°F. for Sicon-Aluminum or black . . . from 500° to 650°F. in gold or other decorative colors. Write for Sicon brochure and free sample offer . . . today! **Write Dept. C-9.**

SICON, protects and preserves—wherever there is heat.

Circle 592 on Page 19

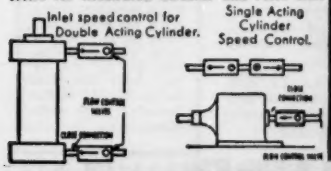
Get Easier, More Accurate Cylinder Speed Control

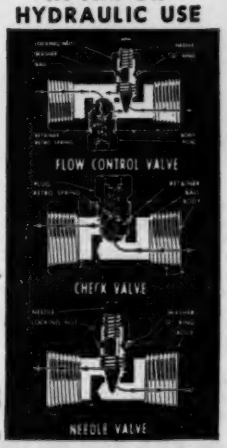
with **Pneu-Trol®** VALVES IN AIR OR HYDRAULIC USE

2,000 (brass or aluminum) and 5,000 (steel) p.s.i.

Pneu-Trol Valves combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to seat, requiring only a slight differential pressure to fully open or close it. Check Valve and Needle Valve incorporate single function features of Flow Control Valve. All valves available in 5 female pipe sizes — 1/8" to 3/4". Valve bodies are made from brass, aluminum, steel or stainless steel. Attractive Prices — Immediate Delivery.

Write for Illustrated Circular and Price List.





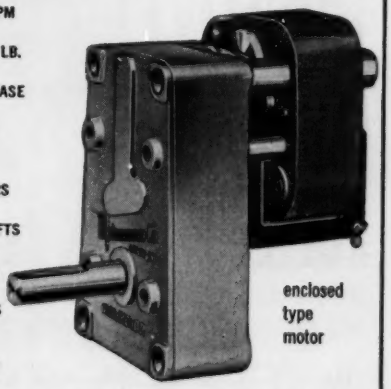
AUTOMATION AUTO-PONENTS INC. COMPONENTS

2925 GRANT STREET
BELLWOOD (Chicago Suburb) ILLINOIS

Circle 593 on Page 19

GEARMOTORS

- SPEED UP TO 200 RPM
- POWER UP TO 40 IN. LB.
- OPEN OR ENCLOSED CASE
- CONTINUOUS OR INTERMITTENT
- MACHINE CUT GEARS
- FINISH GROUND SHAFTS
- MILLIONS IN USE
- SPECIAL FEATURES AVAILABLE
- PROMPT DELIVERY
- SAMPLES AT ONCE
- ASK FOR OUR LITERATURE



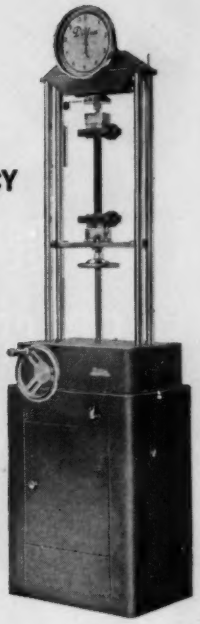
enclosed type motor

MILLIONS OF MOTORESEARCH GEARMOTORS NOW IN USE! Motoresearch also designs and produces high frequency motors, generators, rectifier type power supplies and other Special Electrical Equipment. We invite your inquiries.

MOTORESEARCH COMPANY
1800 JUNCTION AVENUE
RACINE, WISCONSIN
Designers and Manufacturers of
special electrical equipment

Circle 594 on Page 19

AVOID COSTLY ERRORS WITH GUARANTEED *Dillon* ACCURACY WHEN YOU...



TEST...
In TENSILE • COMPRESSION
TRANSVERSE • SHEAR

MEASURE...
In TENSION OR COMPRESSION

OR

CONTROL
TEMPERATURE
(FAHRENHEIT-CENTIGRADE)

Bring ASTM & Federal Accuracy into your own shop
—at a fraction of outside service charges!

YOU DON'T HAVE TO BE AN EXPERT to secure EXPERT results with Dillon instruments. These precision products are calibrated with *Certified* test weights, elastic proving rings and testing machines whose accuracy is directly traceable to the U.S. Bureau of Standards! Every desirable feature is included. Seldom used, expensive extras are eliminated. In the laboratory or on the production line, Dillon equipment will provide you with *vital* test data exactly as you need it—*when* you need it!

VALUABLE FREE ENGINEERING BROCHURES

Write today for ideas on how to safeguard your company against costly material and equipment failures! Specify brochure desired: Model LW Tester ☐ Thermometer ☐ Mechanical Force Gauge ☐

TO MEASURE, WEIGH, TEST OR CONTROL—CALL ON DILLON
...PRECISION INSTRUMENTS FOR 3 DECADES!

W. C. Dillon & COMPANY, INC.

DEPT. 115, 14564 KESWICK STREET, VAN NUYS 73, CALIFORNIA
Representatives in All Principal Cities

Circle 595 on Page 19

through EQUITABLE *research:*

A NEW, DEPENDABLE SOURCE FOR CROWN GROUND PRECISION GEARS, Ssplines

EQUITABLE ENGINEERING

C/G ®T.M.

CROWN GRINDING

Now you can engineer your precision gear and spline jobs to a wide range of crowned requirements—with complete assurance of having a ready, dependable, high-quality source for their production. Equitable's new C/G process is of particular benefit in the designing of missile-rocket gear boxes and precision flexible spline couplings. If you're experiencing a misalignment problem due to varying temperatures or unavoidable loading difficulties, contact Equitable's engineering staff today. We'll be happy to assist you.

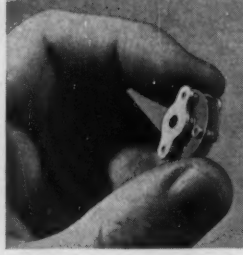
EQUITABLE

ENGINEERING COMPANY
2724 NORMANDY ROAD • ROYAL OAK, MICHIGAN
TELEPHONE LIBERTY 9-5300
Member: American Gear Manufacturers' Association

---

this is a

*RENBRANDT *original*



***the precision-made, miniature-size flexible coupling with ZERO BACKLASH**

This is a TINYMITE Flexible Coupling

Low cost. No backlash. Nylon insulating center piece. For manual controls, tuners, plug-in units, sub-miniaturization, etc. ½" dia. by 11/32" long. Std. sizes for 1/8, 3/16, 1/4" shafts. Special sizes available.

You save space and weight with Renbrandt Miniature Flexible Couplings. They have torsional rigidity, angular and linear flexibility, low inertia . . . and yet are *ENTIRELY FREE OF BACKLASH.* The unique disc-type design assures long life at a moderate price. A complete line is available for 1/16" through ½" shafts in all combinations. Many hub styles, including clamp and set screw.

For exacting requirements specify Renbrandt Couplings. Prompt delivery on prototype or production orders. Send for catalog or send your requirements for quotes.

RENBRANDT

Renbrandt, Inc.
6-D Parmelee St.
Boston 18, Mass.
tel: Highlands 5-8910

Circle 597 on Page 19

Nothing SEALS as POSITIVE!

NYLTITE ®

ROLLED NYLON WASHERS

make a positive seal up to 250°F and can be used with any standard fastener including tapping screws

NYLTITE WASHERS SEAL AND STOP LEAKS
WITHSTAND PRESSURE UP TO 15,000 PSI
RESIST VIBRATION • PREVENT CRAZING
RETARD ELECTROLYSIS AND ARE EXCELLENT FOR INSULATING

(Long, headed sleeves are also available from stock)

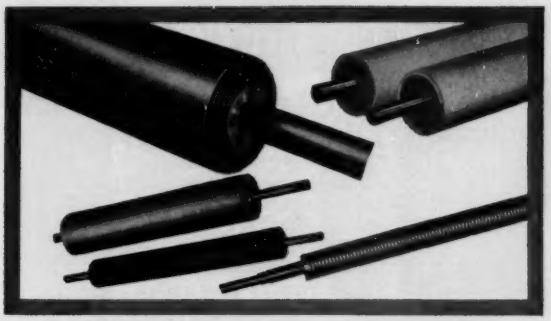
SEND FOR SAMPLES AND LITERATURE NOW!

NYLTITE CORPORATION OF AMERICA

280 BADGER AVENUE • NEWARK 8, NEW JERSEY

Circle 596 on Page 19

Circle 598 on Page 19

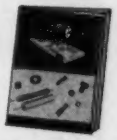


Specify **WILBOW** *for Custom Built Rubber Covered Rolls*

■ WILBOW is fully equipped to recover, or furnish complete with cores, different types of rolls; for glass machine, meat packers, squeegee, steel mill, feed, tanners, office duplicating, photocopy, paper mill and gypsum board and other special machinery.

Roll coverings can be supplied in natural or synthetic rubber stocks including silicone of various hardnesses, compounded to meet your particular problems, in various finishes, such as Smooth, Crepe, Fluted, Corrugated, Grooved, or with outer covering of duck, or in any other finish to better serve the purpose for which the rolls are intended. Let us know of your roll requirements. Our engineers will be pleased to make recommendations.

Send for **New WILBOW Catalog**
It will become your handbook of rubber goods



Wilbow

The WILLIAMS-BOWMAN RUBBER Co.
1951 South 54th Avenue • Cicero 50, Illinois
Mfrs. of molded, punched, extruded and cut rubber goods. Specialists in producing rubber covered rolls, silicone rubber parts and bonding rubber to metal

Circle 599 on Page 19

This Revolving Joint Seals perfectly at any angle the ROTARY UNION*

The Rotary Union can be installed at any angle without putting strain on sealing surfaces. This, plus patented features which automatically compensate for machine wear and adjust to fluctuations in line pressure, make the Rotary Union the most efficient and most durable rotating joint you can buy.

There is a Rotary Union for every heating or cooling application in pipe sizes ¼" through 5". Write for Bulletin 700 today.

*Trade Name—Patented

"WHERE *Good Connections* COUNT"®
PERFECTING SERVICE COMPANY, 332 Atando Ave., Charlotte, N.C.
Baltimore—Buffalo—Camden, N. J.—Chicago—Cleveland—Los Angeles
New York—Providence—Montreal—Toronto

Circle 600 on Page 19

Latest Advance in
SPRING DESIGN

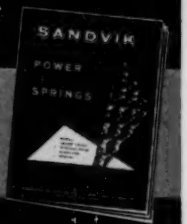
NEW SANDVIK INTEGRAL BAND SPRINGS*

Sandvik's newest development in spring design is a self-contained unit accomplished by mechanically joining together the two outer convolutions of the spring.

Give You These Advantages:

- CAN BE SAFELY INSTALLED OR REPLACED IN SECONDS
- HOLDER OR KEEPER NOT REQUIRED
- MAY ELIMINATE THE NEED FOR BARREL OR HOUSING
- MINIMIZES NORMAL FRICTION
- PROVIDES MORE UNIFORM TORQUE
- PERMITS USAGE OF DIFFERENT SIZES OF SPRINGS IN THE SAME HOUSING FOR DIFFERENT REQUIREMENTS
- SAFER TO INSTALL; BOTH ORIGINALLY AND FIELD REPLACEMENT

*Patent Pending



For more information on these and other Sandvik Power Springs, send for this free 12-page catalog.

SANDVIK STEEL, INC.
Fair Lawn, New Jersey • SWarthmore 7-6200
In New York City • ALgonquin 5-2200
CLEVELAND • DETROIT • CHICAGO • LOS ANGELES

Circle 601 on Page 19

WECKESSER

molded
BLACK NYLON SCREWS *and* **NUTS**

SEE US AT BOOTH 4003 I. R. E. SHOW NEW YORK

Acid resistant . . .
Need no insulation . . .
Can't rust . . .
Can't corrode . . .

● **CUT ASSEMBLY TIME**

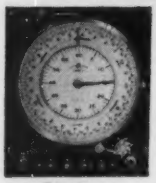
2-56, 4-40, 6-32, 8-32, 10-32 and ¼-20 in stock. Actual production samples will give you the whole story. Write on your letterhead.

WECKESSER COMPANY
5715 Northwest Hwy. • Chicago 46, Ill.

Circle 602 on Page 19

Safeguard Time Controlled Operations

with **ZENITH** *automatic accuracy*

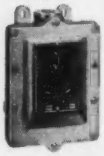


Program Timers

Automatic Reset Timers

Interval Timers

Process Timers



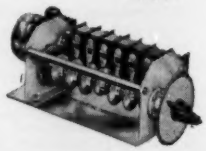
Explosion-Proof Timers

Zenith Automatic Control Equipment provides a full line of the most accurate and reliable timing devices available to industry. This precision-engineered equipment features field-proven design, simple construction and . . . most important . . . years of completely dependable maintenance-free service.

Whatever your timing requirement . . . program, interval, reset, multiple circuit, process or explosion-proof . . . remember that Zenith is the recognized specialist . . . also day or calendar switches, automatic and remote control switches, contactors and all types of special electrical control equipment.

Write for latest Bulletin

See classified telephone directory for Factory Representative

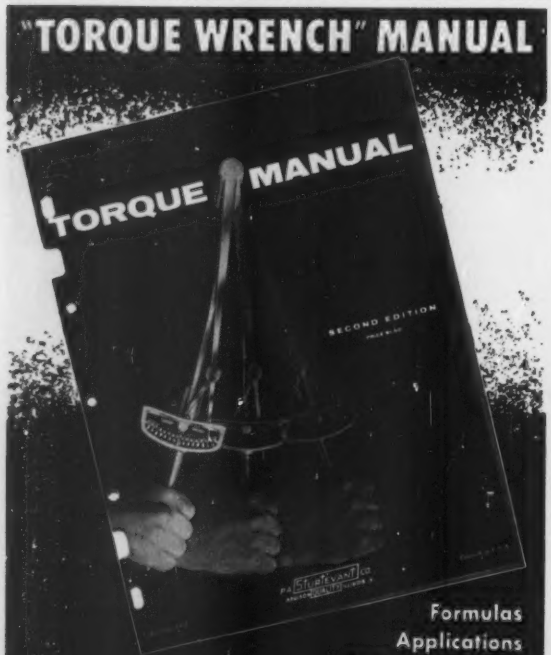


Multicircuit Timers

ZENITH ELECTRIC CO.

Circle 603 on Page 19

"TORQUE WRENCH" MANUAL



SENT UPON REQUEST

Formulas
Applications
Engineering Data
Screw Torque Data
Adapter Problems
General Principles

PA STURTEVANT CO.
ADDISON QUALITY ILLINOIS

Manufacturers of over 85% of the torque wrenches used in industry

WHAT'S YOUR PROBLEM ?

PARTS? MATERIALS? COMPONENTS? FINISHES?

Perhaps one of our advertisers in this issue of MACHINE DESIGN has the solution to your dilemma. We'll be willing to bet that this issue contains information that is essential to answering your problem.

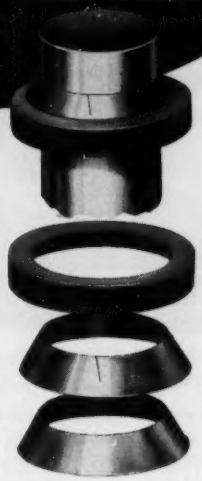
Fill out one of the yellow inquiry cards and send it to us. No letter or postage is necessary. We will forward your inquiry to the advertiser and he will reply directly to you.

Why not do it right now?

USE THE YELLOW CARD ON PAGE 19.

Circle 604 on Page 19

PROTECT VITAL HYDRAULIC PARTS with *Seal-Guard* METALLIC ROD WIPERS



Bronze, knife-edged rings, mounted in a synthetic rubber cushion ring, remove rust, scale and foreign particles before they can reach vital internal parts. The cushion ring, compressed on assembly, exerts constant pressure on the bronze rings. Rings will not mar the rod, are oil and heat resistant and friction-free. Packing failures are literally "wiped out"!

Available in standard sizes for ¼ to 6 inch rod diameters. Larger sizes up to 24½" diameter by special order.

Detailed literature on request

HYDRAULIC ACCESSORIES CO.
24301 Hoover Road Warren, Michigan

Circle 606 on Page 19

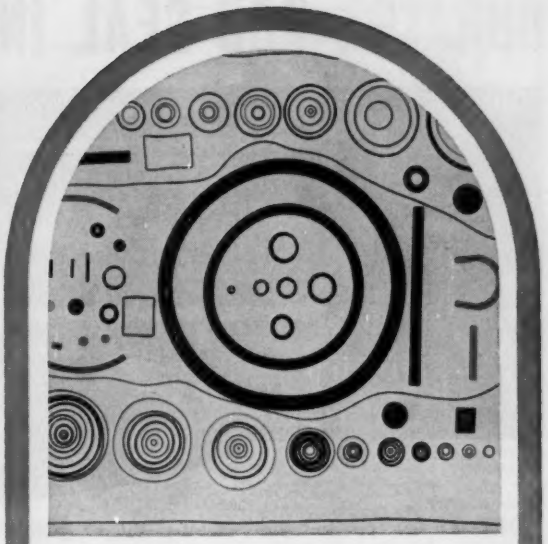
Why wait for delivery on spiral bevel gears? ARROW ships from a full stock of common sizes, in ratios: 1 to 1 • 2 to 1 • 3 to 1 • 3 to 2 and 4 to 3. Gear sizes of 1.000 to 13.000 pitch dia. Teeth are precision matched, case hardened and crown lapped. Sets are precision made, high speed tested.

WRITE FOR ENGINEERING MANUAL

ARROW *Gear Company*

2301 Curtis Street • Downers Grove, Illinois

Circle 607 on Page 19



Mr. Design Engineer:

we pull the rug out from under *rugged* problems involving

Precision Molded Parts

Design engineers' problems involving custom-designed, precision molded parts for hydraulic and pneumatic systems . . . especially the tough ones . . . are welcomed at AERO GASKET. Molded parts of rubber compounds such as Viton, silicones, buna N, and Neoprene in an infinite variety of shapes and sizes can be supplied for components that must operate at temperatures as low as —65°F or up to 600°F. High and low temperature plastics such as Teflon and Kel F are also used by AERO GASKET in developing molded parts that conform to the most demanding tolerances. All compounds are controlled by ASTM test methods. SEND SPECS AND BLUEPRINTS FOR PROMPT QUOTATIONS.

MAIL COUPON FOR DATA SHEETS

THE AERO GASKET CORPORATION
33 Hanover Street, Meriden, Conn.

☐ Please send me the Data Sheets describing Aero Gasket Precision Molded Parts.

I am also interested in:

☐ Precision Metal Parts ☐ Seals and Gaskets
☐ Diaphragms and Diaphragm Assemblies

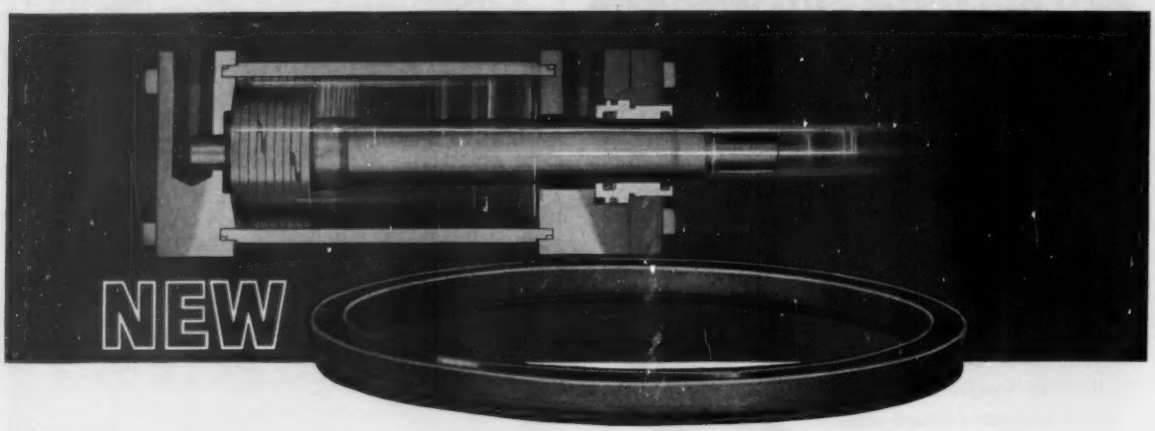
name_____
company_____
co. address_____
city_____ zone____ state_____

THE
AERO Gasket
CORPORATION
Meriden, Connecticut

DIAPHRAGMS • ACTUATORS • ACCUMULATORS
METALLIC & NONMETALLIC GASKETS
CLAMPS OF ALL TYPES AND DESCRIPTIONS
MOLDED RUBBER PARTS • METAL STAMPINGS • METAL-TO-RUBBER BONDING

Circle 608 on Page 19

DURATON ROD SEAL IN HYDRO-LINE CYLINDERS



Here is a new opportunity to reduce machine downtime and costs caused by cylinder leakage or scoring: Hydro-Line's "Duraton" rod seal — exclusive durability formed from Viton®, guarded by backup washer of carbon-impregnated Teflon.

Leakproof seal is assured by superior resistance of "Duraton" rod seal-backup washer combination to abrasives, corrosives, and pressure. Retains effective resiliency at temperatures to 400°F and higher. Compatible with virtually all hydraulic fluids. Resists aging.

Iron-oxide-colored "Duraton" rod seals, Ebalon backup washers, and Viton wipers are standard on Hydro-Line Series N2 hydraulic cylinders to 5000 psi. See your Hydro-Line representative for details.

HYDRO-LINE

® Registered trademark of E. I. DuPont De Nemours & Company, Inc.

5602 PIKE ROAD, ROCKFORD, ILLINOIS, manufacturers of: high- and low-pressure hydraulic cylinders • heavy-duty air cylinders • boosters • adjustable-stroke cylinders • dispensing cylinders • single-acting cylinders • rod end couplers

Circle 609 on Page 19

MECHANICAL ENGINEERS

Bausch & Lomb

There are several openings for Senior Design Engineers in the Product Design sections of our company.

These positions require board design, coordination of customer requirements with Electrical and Optical Designers, supervision of detail draftsmen, assistance to shop during construction and assembly as well as testing and development work.

Those who can qualify and are interested in real design responsibility are invited to submit a resume to: Mr. H. A. Frye, Professional Employment.

Bausch & Lomb

INCORPORATED

13 Bausch Street • Rochester 2, New York

ENGINEERS AVAILABLE OR WANTED

WANTED: Mechanical Engineer. Mechanical Engineer to join an expanding engineering department, specializing in the design of twisting, stranding, and cabling machinery. Must have experience in the design or maintenance of such machines. Position requires creative ability and training necessary to solve problems arising in such designs. Excellent salary. The Edmands Company, 860 Wellington Avenue, Cranston 10, Rhode Island.

AVAILABLE: Design Engineer for board work. Offering you competence, ability and twenty years' experience on design of product, power press dies, automatic and other machinery, production tools; quality draftsmanship; ingenuity and originality on development of ideas. Temporary engagements or projects. Fee basis. Any location. Address: Boxholder, 202 Back Bay Postal Annex, Boston, Massachusetts.

WANTED: Automatic Assembly Machine Design and Development Supervisor. Position for experienced man in the design and development of high speed automatic processing and assembling machines, having the following qualifications: Engineering degree, minimum five years machine design experience, minimum four years machine shop experience, minimum three years of supervising and administration. An excellent opportunity in a key position involving the supervision of 12 to 15 machine designers plus the development and assembly shop personnel in a well established company producing automatic machines exclusively. Write Box 988 in care of MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio, outlining complete experience and educational background. All replies held in strict confidence.

Advertising Index

AE Industrial Division, Aircraft Armaments, Inc. 192
Aero Gasket Corporation, The 267
Aeroquip Corporation, Industrial Division 81
Airborne Accessories Corporation 211
Aircraft Armaments, Inc., AE Industrial Division 192
Ajusto Equipment Co. 262
Amchem Products, Inc. 122, 123
American Chain & Cable Co., Inc , Automotive and Aircraft Division 92
American Machine & Foundry Co., Potter & Brumfield Division 66, 67
American Machine and Metals, Inc., The Lamb Electric Co. Division 96
AMP, Inc. 62
Amplex Division, Chrysler Corporation 261
Armstrong Cork Co., Industrial Division 97
Arrow Gear Co. 267
Aurora Pump Division, The New York Air Brake Co. 48
Automatic Electric 60
Automatic Switch Co. ..... Inside Front Cover
Automotive and Aircraft Division, American Chain & Cable Co., Inc. 92
Auto-Ponents, Inc. 263
Avdel, Inc. 229

Barber-Colman Co. 198, 199
Barksdale Valves, Control Valve Division .. 252
Bausch & Lomb, Inc. 268
B & K Instruments, Inc. 72
Bellows-Valvair, Division of International Basic Economy Corporation 95
Bendix-Westinghouse Automotive Air Brake Co. 70
Borg-Warner Corporation, Pesco Products Division 223
Bridgeport Brass Co., Cored Forgings Division 216
Briggs & Stratton Corporation 16
Brooks & Perkins, Inc. 222
Bruning, Charles, Co., Inc. 207

Cambridge Wire Cloth Co., The 235
Century Electric Co. 126, 127
Chain Belt Co. 29
Champion Rivet Co., The 120
Chicago Forging & Manufacturing Co. 243
Chrysler Corporation, Amplex Division 261
Cincinnati Gear Co., The 82
Clare, C. P., & Co. 91
Clearprint Paper Co 65
Colorado Oil and Gas Corporation, Marsh Instrument Co. Division 187
Cone-Drive Gears Division, Michigan Tool Co. 64
Controls Company of America, Control Switch Division 183
Control Switch Division, Controls Company of America 183
Corning Glass Works 237
Crawford Fitting Co. 61
Crown Gear, A Division of Harrington & Richardson, Inc. 42
Curtis Universal Joint Co., Inc. 218

Dahl, G. W., Co., Inc. 206
Dayco Corporation, Dayton Industrial Products Co., Division 87
Dayton Industrial Products Co., Division of Dayco Corporation 87
Detroit Power Screwdriver Co. 233
Deublin Co. 260
Diamond Chain Co., Inc. 80
Diehl Manufacturing Co. 53
Dietzgen, Eugene, Co. 50
Dillon, W. C., & Co., Inc. 263
Dimco-Gray Co. 262
Dixon Corporation 271
Dormeyer Industries 200
Durez Plastics Division, Hooker Chemical Corporation 239
Dynamatic Division, Eaton Manufacturing Co. 119

Eagle Signal Co., A Division of The Gamewell Co. 197
Eaton Manufacturing Co., Dynamatic Division 119
Elastic Stop Nut Corporation of America 98
Electro Devices, Inc., Servospeed Division .. 214
Equipment Sales Division, Raybestos-Manhattan, Inc 186
Equitable Engineering Co. 264

Fafnir Bearing Co., The 55, 56, 57, 58
Farmer Electric Products Co., Inc. 191
Fellows Gear Shaper Co., The 244
Fenwal, Inc. 112
Flexible Tubing Corporation 205
Flick-Reedy Corporation, Miller Fluid Power Division 89
Flick-Reedy Corporation, Tru-Seal Division .. 259

Gamewell Co., The, Eagle Signal Co. Division 197
Gates Rubber Co., The 35
General American Transportation Corporation, Parker-Kalon Division 114, 115
General Aniline & Film Corporation, Ozalid Division 63
General Electric Co. 9
General Electric Co., Miniature Lamp Department 219
General Electric Co., Semiconductor Products Department 272
General Fittings Co. 258
General Industries Co., The 216
General Motors Corporation, Saginaw Steering Gear Division 71
Gillen, John, Co. 246
Gillett & Eaton, Inc. 220
Goshen Rubber Co., Inc. 260
Great Lakes Steel Corporation, Division of National Steel Corporation 208, 209
Gries Reproducer Corporation 259
Groov-Pin Corporation 124

Hamilton Foundry, Inc. 201
Handy & Harman 106
Harrington & Richardson, Inc., Crown Gear Division 42
Hartwell Corporation, The 200
Haynes Stellite Co., Division of Union Carbide Corporation 43
Heli-Coil Corporation 190
Hilliard Corporation, The 238
Hitchiner Manufacturing Co., Inc. 210
Hoke, Inc. 103
Hooker Chemical Corporation, Durez Plastics Division 239
Houghton, E. F., & Co. 52
Howard Industries, Inc. 206
Hunt Valve Co., Division of IBEC 113
Hydraulic Accessories Co. 267
Hydro-Line Manufacturing Co. 268

IBEC, Hunt Valve Co. Division 113
Illinois Tool Works, Licon Division 83
Imperial-Eastman Corporation 242, 243
Industrial Tectonics, Inc., Ball Division 248
Industrial Timer Corporation, Line Electric Co. Division 210
Ingersoll-Rand 68
International Basic Economy Corporation, Bellows-Valvair Division 95
International Nickel Co., Inc., The 59

Jerpbak Bayless 260
Johns-Manville 110
Joy Manufacturing Co 77

Kaydon Engineering Corporation, The 21
Keystone Steel & Wire Co. 93

Lamb Electric Co., The, A Division of American Machine and Metals, Inc. 96
Laminated Shim Co., Inc., The 121
LaSalle Steel Co. 7
Lau Blower Co., The 37, 38
Lewellyn Manufacturing Co. 15
Licon, Division of Illinois Tool Works 83

MACHINE DESIGN
Penton Building, Cleveland 13, Ohio
Main 1-8260

BUSINESS STAFF

ROBERT L. HARTFORD
Publisher

RICHARD A. TEMPLETON
Director, Research & Promotion

MARY L. CALLAHAN
Advertising Service Manager

BARBARA O'LEARY
Staff Assistant

AMY LOMBARDO
Circulation Manager

ROBERT E. LESSING
Production Manager

District Offices

New York 17 .....60 East 42nd St.
RUSSELL H. SMITH, JAMES A. STANGARONE
Murray Hill 2-2581

Simsbury, Conn. .....17 Deerfield Lane
ALAN C. BUGBEE
Oldfield 8-4764

Rochester 18, N. Y. .....119 Willowcrest Drive
GEORGE M. ISBELL
Ludlow 6-7658

Dresher (Philadelphia), Pa. ....1335 Harris Rd.
CHANDLER C. HENLEY
Mitchell 6-2585

Cleveland 13 .....Penton Bldg.
JACK W. WALTON, DON J. BILLINGS
Main 1-8260

Detroit 35 .....15800 West McNichols Rd.
H. F. SMURTHWAITE
Broadway 3-8150

Chicago 11 .....520 North Michigan Ave.
HOWARD H. DREYER, ROBERT Z. CHEW
DONALD A. IVINS, CHARLES F. REINER
Whitehall 4-1234

Los Angeles 36 .....5943 West Colgate Ave.
F. J. FULLER
Webster 1-6865

San Francisco 4 .....57 Post St.
Robert W. Walker Co.
Sutter 1-5568

Birmingham 9 .....249 La Prado Place
FRED J. ALLEN
Tremont 1-8598

Clearwater, Fla. .....1954 Jeffords Dr.
H. G. ROWLAND
(Clearwater) 441-4121

Dallas 35 .....818 Exchange Bank Bldg.
JAMES H. CASH
Fleetwood 1-4523

London, S.W.1 .....2 Coxton St., Westminster

Published by
THE PENTON PUBLISHING COMPANY

G. O. HAYS .....Chairman
R. C. JAENKE .....President
F. G. STEINEBACH ....Vice Pres. and Secretary
F. O. RICE .....Vice President
J. P. LIPKA .....Vice Pres. and Treasurer
D. C. KIEFER .....Vice Pres.—Marketing
I. H. SUCH .....Vice Pres.—Editorial

Also Publisher of
STEEL, FOUNDRY, NEW EQUIPMENT DIGEST, AUTOMATION

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

BPA NBP

backtalk——

—Approval of Seals

About a month after our *Seals Book* was mailed, we sent a questionnaire to a cross section of MACHINE DESIGN readers to learn what use was being made of the book and if anybody had suggestions for changes or additions to future editions. Response was gratifying, and we thank everyone who returned a questionnaire. Special thanks also go to those who sent us unsolicited comments.

Readers told us that they had used the book to "get off the hook" on a sealing problem, planned to use it in training programs, and generally intend to keep it handy. One man vows to break the arm of anyone who tries to make off with his copy. Such violence is not necessary, however, because extra copies are available at small cost.

—Bearings' Turn

The third volume in our reference-manual series will be the *Bearings Book*. Like the previous handbooks, it has a Design Data section and a Product Directory. Seventeen chapters are full of information on designing, selecting, and applying bearings, and the cross-indexed directory lists bearing types, tradenames, and manufacturers.

The *Bearings Book* is going to press now and will be in your bookcase soon.

—Snow-Blind, Maybe?

Mr. C. G. Hockett, chief production engineer of the Fram Corp., Providence, R. I., writes:

> In the description of the "Snowblast" (Feb. 2, Page 28) it says that with helical blades revolving at a surface speed up to 50 fpm, it provides plowing rates up to 30 mph. I can't accept this. At 30 mph, the Snowblast will have moved 2640 ft while the helical blades have covered only 50 ft.

Indeed, Mr. Hockett, we can't expect you to accept it, and we thank you for reading this sentence carefully, which is more than some of us did. Obviously, it should have said 50 fps.

Incidentally, the Snowblast was so interesting that, besides showing a picture, we decided to explore its innards. This is done in accurate detail on Page 152.

—Gravity and Gelt . . .

Are you "seriously interested in the application of gravity to practical uses for the benefit of humanity"? If so, you are eligible to submit an essay to the Gravity Research Foundation's 1961 Awards for Essays on Gravity. The five best 1500-word-or-less essayists will receive from $1000 to $100. Subject should deal with the possibilities of discovering some partial insulator, reflector or absorber of gravity; some alloy, or other substance, the atoms of which can be agitated or rearranged by gravity to throw off heat; or some other reasonable method of harnessing, controlling, or neutralizing gravity. Essays should be received before April 15 by Gravity Research Foundation, New Boston, N. H.

. . . and Cash for Casting

Another competition with a mid-April deadline is the Annual Doehler Award for outstanding contributions to the advancement of the die casting art. Any individual, group, educational institution, or scientific society or committee is eligible for nomination. The award will be a plaque and at least $500. Information is available from Award Committee, American Die Casting Institute, 366 Madison Ave., New York 17, N. Y.

—A Goat by Any Other Name

We see by the News in this issue that computers are growing more clever all the time. However, one that was recently put to work as a translator turned out to be somewhat short on technical vocabulary. It kept repeating the phrase "water goat," which, of course, should have been "hydraulic ram."

Advertising Index

Lincoln Engineering Co., Division of The McNeil Machine & Engineering Co. 107
Line Electric Co. Division, Industrial Timer Corporation 210
Ling Electronics Division, Ling-Temco Electronics, Inc. 44, 45
Ling-Temco Electronics, Inc., Ling Electronics Division 44, 45
Link-Belt Co. 11
Lockheed/Missiles and Space Division 249
Long-Lok Corporation 257
Lord Manufacturing Co. 215
Lucas-Rotax Limited 108
Lyon Metal Products, Inc. 261

McNeil Machine & Engineering Co., The, Lincoln Engineering Co. Division 107

Madison-Kipp Corporation 86
Malayan Tin Bureau, The 189
Manhattan Rubber Division, Raybestos-Manhattan, Inc. 84
Marsh Instrument Co., Division of Colorado Oil and Gas Corporation 187
Mead Specialties Co. 1
Meehanite Metal Corporation 234
Michigan Tool Co., Cone-Drive Gears Division 64
Micro Switch Division, Minneapolis-Honeywell Regulator Co. 195
Midland Industrial Finishes Co. 262
Midvale-Heppenstall Co. 5
Milford Rivet & Machine Co., The 218
Miller Fluid Power Division, Flick-Reedy Corporation 89
Minneapolis-Honeywell Regulator Co., Micro Switch Division 195
Minnesota Rubber 2
Mirro Aluminum Co. 109
Moore, George, W., Inc. 262
Morse Chain Co. 185, 187, 189, 191
Motoresearch Co. 263
Mueller Brass Co. 102

National Acme Co., The 69
National Screw & Mfg. Co., The 78
National Steel Corporation, Great Lakes Steel Division 208, 209
National Vulcanized Fibre Co. 111
New Hampshire Ball Bearings, Inc. 74
New Jersey Zinc Co., The 128
New York Air Brake Co., The, Aurora Pump Division 48
Norgren, C. A., Co. 40, 41
Nyltite Corporation of America 264

Ohmite Manufacturing Co. 33
Ortman-Miller Machine Co. 214
Ozalid, Division of General Aniline & Film Corporation 63

Packings Division, Raybestos-Manhattan, Inc. 85
Parker Fittings and Hose Division, Parker Hannifin Corporation 90
Parker Hannifin Corporation, Parker Fittings and Hose Division 90
Parker-Kalon, A Division of General American Transportation Corporation 114, 115
Penn Engineering & Manufacturing Corporation 118
Perfecting Service Co. 265
Perkins Machine and Gear Co. 236
Pesco Products Division, Borg-Warner Corporation 223
Pheoll Manufacturing Co., Inc. .. Inside Back Cover
Philadelphia Gear Corporation 251
Plastic Products Division, Raybestos-Manhattan, Inc. 85
Polar Ware Co. 256
Polymer Corporation of Pennsylvania, The .. 228
Potter & Brumfield, Division of American Machine & Foundry Co. 66, 67
Protective Closures Co., Inc., Caplugs Division 213
Purolator Products, Inc. 54

Quaker State Metals Co. 241
Quinn-Berry Corporation 31

Racine Hydraulics & Machinery, Inc., Hydraulics Division 225, 226, 227
Rae Motor Corporation 260
Raybestos-Manhattan, Inc., Equipment Sales Division 186
Raybestos-Manhattan, Inc. 84, 85
Recordak Corporation 125
Reliance Electric and Engineering Co. 247
Renbrandt, Inc. 264
Republic Steel Corporation 104, 105
Robbins & Myers, Inc. 73
Roper Hydraulics, Inc. 188

Saginaw Steering Gear Division, General Motors Corporation 71
Sandvik Steel, Inc. 265
Schrader's, A., Son, Division of Scovill Manufacturing Co., Inc. 217
Scovill Manufacturing Co., Inc., A. Schrader's Son Division 217
Servometer Corporation 261
Servospeed, Division of Electro Devices, Inc. 214
Sier-Bath Gear and Pump Co., Inc., Flexible Coupling Division 259
Sigma Instruments, Inc. 245
Simmons Fastener Corporation 94
Skinner Electric Valve Division, Skinner Precision Industries, Inc. 75, 76
Skinner Precision Industries, Inc., Skinner Electric Valve Division 75, 76
Snow-Nabstedt Gear Corporation 246
Sperry Rand Corporation, Vickers, Inc., Division, Electric Products Division 99
Staedtler, J. S., Inc. 253
Stearns Electric Corporation 212
Sterling Electric Motors, Inc. 193
Sturtevant, P. A., Co. 266
Sylvania Electric Products, Inc., Parts Division 116, 117
Synthane Corporation 255

Taylor Fibre Co. 100, 101
Timken Roller Bearing Co., The, Steel and Tube Division ..... Back Cover
Tinnerman Products, Inc. 221
Titchener, E. H., and Co. 254
Torq Engineered Products, Inc. 220
Torrington Co., The 13
Tru-Seal Division, Flick-Reedy Corporation .. 259
Twin Disc Clutch Co., Hydraulic Division 232

Union Carbide Corporation, Haynes Stellite Co. Division 43
Union Carbide Corporation, Silicones Division 49
Union Carbide Corporation, Union Carbide Plastics Co. Division 203
Union Carbide Plastics Co. Division, Union Carbide Corporation 203

Vickers, Inc., Division of Sperry Rand Corporation, Electric Products Division 99
Victor Mfg. & Gasket Co. 79

Waldes Kohinoor, Inc. 51
Wapakoneta Machine Co., The 196
Ward Leonard Electric Co. 240
Waterman Hydraulics Corporation 222
Watlow Electric Mfg. Co. 231
Weckesser Co. 266
White, S. S., Industrial Division 224
Williams-Bowman Rubber Co., The 265
Winsmith, Inc. 88
Wolverine Tool Co. 192

Youngstown Sheet and Tube Co., The 46, 47

Zenith Electric Co. 266

Engineers Available or Wanted 268

RULON® AND TEFLON®

RULON'S "Plastic Memory" Means Tighter Seals . . . Lower Costs

RULON (reinforced TFE) parts post-formed from tape are ideal for seals, packings, rings, etc. because they exhibit no stick-slip and greatly reduce starting torque. And unlike rubber or leather, RULON takes any hydraulic fluid – and its plastic memory insures positive contact with shafts or cylinder walls. Parts have infinite shelf life, too – completely unaffected by weather, light or heat.

Dixon's self-lubricating RULON gives your sealing applications all the advantages of Teflon – low friction, chemical inertness, zero moisture absorption, extreme temperature range (−400 to +500°F) – PLUS a tremendous increase in mechanical strength and wear resistance.

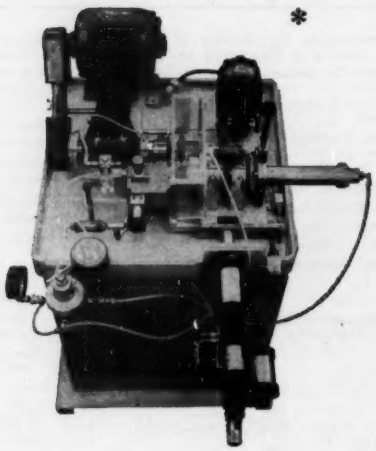
Next time, look at your design with RULON in mind. This material is now available with improved sealing action and at costs competitive with leather and rubber. For complete data on stamped or post-formed parts . . . special reinforced fluorocarbons for special needs . . . and a wide selection of basic shapes in both RULON and Teflon . . . see our Catalog in Sweet's Product Design File, or write for Brochure #9572. DIXON CORPORATION, 100 BURNSIDE ST., BRISTOL, R. I.

* DuPont T.M.

DIXON

Circle 611 on Page 19

MORE THAN 60% OF ALL GRADUATE ME's READING THIS MESSAGE CAN QUALIFY IMMEDIATELY FOR NEW OPENINGS IN THE SEMICONDUCTOR FIELD AT GENERAL ELECTRIC



The spectacular growth of the semiconductor industry—doubling in size every three years—depends, to a great extent, upon the successful development of many unusual types of high speed automatic manufacturing and test equipment.

A high order of engineering innovation is demanded by the new and unusual characteristics of semiconductors—their small overall size, "measured-to-millionths" components, contamination safeguards, precise positioning and joining, capping, sealing and mass testing, to mention only a few.

As a result, scientists and engineers from many fields are finding their skills "convertible"—sufficiently so to immediately qualify them for the greater challenges and rewards of this growth industry.

The experienced BS or MS Mechanical Engineers we seek may now be working in such diverse areas of automation and control engineering as shoe manufacturing, chewing gum processing, cigarette manufacturing, or industries engaged in high quantity watch or small instrument manufacturing.

NOTE ON GROWTH

General Electric's Semiconductor Products Department is surpassing the industry growth rate—currently undergoing expansion which will double its professional staff in the next two years. During 1961, new facilities in Syracuse will be completed, increasing our space three-fold.

To apply, or get information on specific opportunities related to your background and interests, write in confidence to Mr. J. H. McKeehan, Dept. 72-WK

SEMICONDUCTOR PRODUCTS DEPARTMENT

GENERAL ELECTRIC

ELECTRONICS PARK SYRACUSE, NEW YORK

* Rotary Wafer Slicing Machine, developed here, cuts thin wafers of silicon or germanium automatically with extreme reproducibility. Thin diamond wheels conserve the precious material and raise the yield of wafers per crystal section by 35%.

and here's how Pheoll solved it

It's no picnic . . . this rising cost of labor and material . . . especially to a cost-control engineer.

However, new ways are constantly being found to improve quality while cutting expenses. In this instance a cost-conscious engineer, working closely with a Pheoll Sales Engineer, discovered how he could save his company money on a brass terminal item.

The fastener in the picture formerly had a hole drilled laterally through the head, into which a wire was inserted and soldered. It was necessary also to prevent the terminal from turning as the nut was tightened.

Pheoll facilitated the assembly operation by producing a brass terminal with special lugs under the head to prevent turning . . . and also incorporated a wide slot, instead of a hole, in the head to speed and simplify the wire connection when soldering.

Result was the reduction in cost of producing this fastener by 66%. One more example of the cost-conscious quality engineering . . . custom work you can expect . . . when you bring your fastener problems to Pheoll.

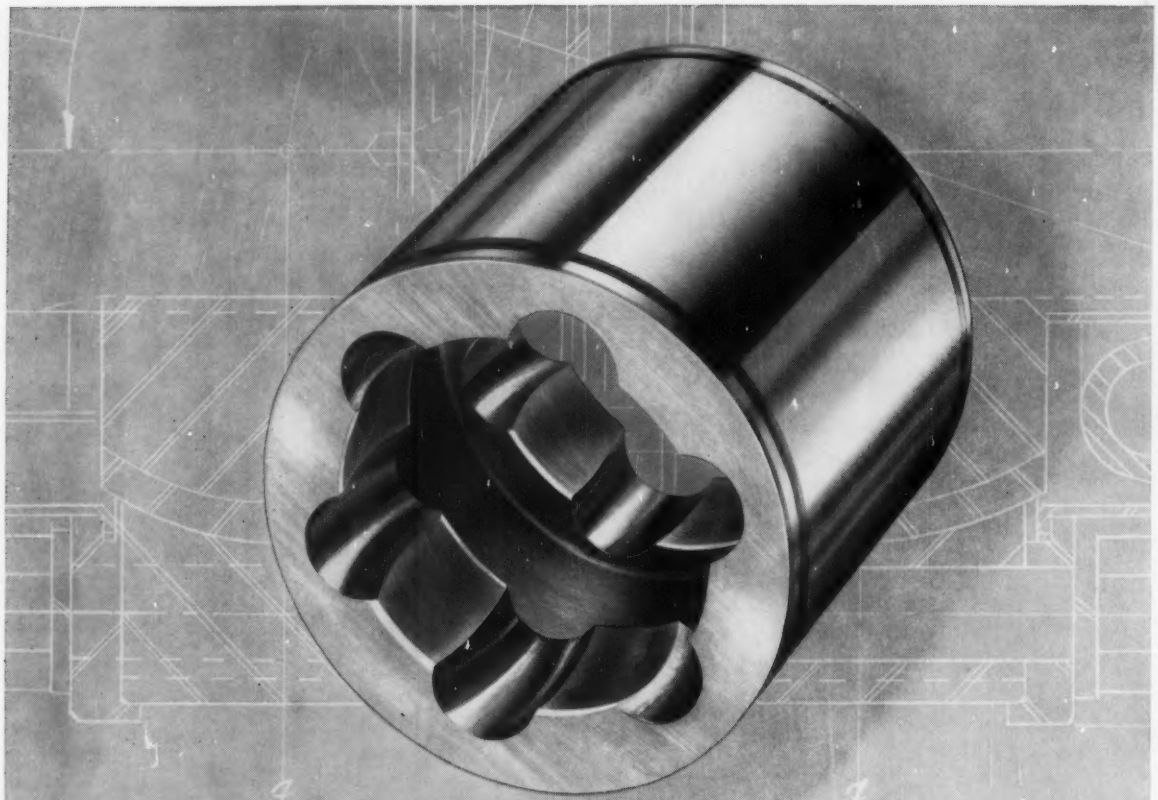
Pheoll Manufacturing Company, Inc.

5700 WEST ROOSEVELT ROAD CHICAGO 50, ILLINOIS

PHEOLL P

HEADING THE FASTENER INDUSTRY FOR OVER 50 YEARS

Circle 402 on Page 19



How Dana cut cost but not quality of universal joint

Before the development of the constant velocity universal joint, transmitting uniform rotary motion through a varying angle from shaft to shaft was unsatisfactory at best. Now this type of joint has hundreds of successful applications, including marine and aircraft, road building and mining machines, and machine tools. And with Dana Corporation's Con-Vel Division Rzeppa universal joints, motion transmission is virtually vibration-free. Their disc-type double joint, made from two forged and machined single units coupled together, had one probem—high manufacturing cost. Dana wanted to reduce this cost while maintaining quality.

After consulting with Timken Company metallurgists, Dana redesigned and switched to Timken® seamless steel mechanical tubing for the double outer race of the disc. Savings were immediate and sizable. With the tubing, there's no hole to drill, less machining. Quality was maintained and strength actually increased because of the fine forged quality of Timken rotary-pierced tubing.

Find out how versatile Timken seamless steel tubing—targeted during manufacture to your end use—can save you time and money on your hollow parts. Write: The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

TIMKEN®
***Fine Alloy* STEEL**

TIMKEN ALLOY STEEL AND SEAMLESS STEEL TUBING ARE AVAILABLE FROM STEEL SERVICE CENTERS IN 44 CITIES IN THE UNITED STATES

Circle 403 on Page 19